Bulletin No. 261

Series { A, Economic Geology, 54
E, Chemistry and Physics, 45

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

PRELIMINARY REPORT

ON THE OPERATIONS OF THE

COAL-TESTING PLANT

OF THE

UNITED STATES GEOLOGICAL SURVEY

AT THE

LOUISIANA PURCHASE EXPOSITION, ST. LOUIS, MO., 1904

EDWARD W. PARKER, JOSEPH A. HOLMES, MARIUS R. CAMPBELL

COMMITTEE IN CHARGE

WASHINGTON

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
COAL-TESTING PLANT, WORLD'S FAIR GROUNDS,
St. Louis, Mo., January 31, 1905.

SIR: The undersigned, appointed by you as a committee to conduct a series of tests at the United States Geological Survey coal-testing plant on the World's Fair Grounds, St. Louis, Mo., have the honor to submit the following preliminary report on the operations of the plant. The brief statements give the results obtained from September 1, 1904, when the plant was put in operation, until December 22, 1904.

The detailed report, which will be fully illustrated and contain much additional information and a discussion of the results, is in preparation and will be submitted to you at the earliest possible date.

Very respectfully,

E. W. PARKER,
J. A. HOLMES,
M. R. CAMPBELL,
Committee.

HON. CHARLES D. WALCOTT,
Director United States Geological Survey.

PRELIMINARY REPORT ON THE OPERATIONS OF THE COAL-TESTING PLANT OF THE UNITED STATES GEOLOGICAL SURVEY AT THE LOUISIANA PURCHASE EXPOSITION, ST. LOUIS, MO., 1904.

EDWARD W. PARKER,
JOSEPH A. HOLMES,
MARIUS R. CAMPBELL,
Committee in Charge.

INTRODUCTION.

ORGANIZATION.

The authority for conducting at the Louisiana Purchase Exposition an investigation of the coals and lignites of the United States is contained in the act of Congress providing for the urgent deficiencies in the appropriations for the fiscal year 1905, and approved February 18, 1904, as follows:

> For analyzing and testing at the Louisiana Purchase Exposition the coals and lignites of the United States, in order to determine their fuel values and the most economic method for their utilization for different purposes, under the supervision of the Director of the United States Geological Survey, thirty thousand dollars, to be available until expended: *Provided,* That all testing machinery and all coals and lignites to be tested shall be contributed without charge to the Government.

In the general deficiency bill approved April 27, 1904, an additional appropriation of $30,000 was provided, making the total sum appropriated for this work $60,000.

For carrying out the provisions of these acts the Director of the Geological Survey appointed a committee, consisting of Edward W. Parker, chairman, Joseph A. Holmes, and Marius R. Campbell, to direct the construction and operation of the plant.

It will be observed that under the law authorizing this work all of the testing machinery and all of the coals to be tested had to be furnished to the Government free of charge. Under these conditions it was not possible to equip an ideal testing plant, and the assembling and construction of such equipment as could be obtained under these provisions entailed some annoying delays in the completion of the

plant. In addition to this, the delivery of a considerable quantity of operating and conveying apparatus purchased from the Link Belt Machinery Company, of Chicago, was delayed by a strike in the works of that company. As a result of these combined influences the plant was not put in operation until the first of September.

Notwithstanding these delays, the committee feels that through the hearty and patriotic cooperation of a large number of manufacturers of apparatus and machinery, it was able to collect and install, within a notably short time, a testing plant that was well suited for such pioneer work.

BUILDINGS.

The buildings for the housing and protection of the machinery and of the operators in charge, with the exception of the chemical laboratory, were built by contract and paid for out of the appropriation. These buildings were:

(1) A boiler and engine house, in which were installed 2 Heine safety boilers, 1 Frost boiler, 1 Allis Corliss steam engine, 1 Westinghouse gas engine, 1 Bullock generator, 1 Westinghouse generator, an electric switchboard, a gas-analyzing laboratory, and all the incidental apparatus pertaining to the operations of these portions of the plant. The contract price for the construction of this building was $2,700. It was built by the Barwick Construction Company, of St. Louis.

(2) A storage and washery building, in which were installed 5 storage bins of 35 tons capacity each, 2 coal washers, 1 revolving screen, 1 set of crushing rolls, 1 pulverizer, 1 Frost steam engine, 1 hopper scale, and the conveying machinery adapted for such a plant. This building, which had to be of extra strong material and construction, was completed at a contract cost of $4,550, the Settle-Price Construction Company, of St. Louis, being the contractor.

(3) Two buildings for briquetting machines and equipment, one built by the Baerveldt Construction Company, of St. Louis, for $1,050, and the other by the Barwick Construction Company, of St. Louis, for $693.

In the letting of all contracts, bids were obtained from at least five responsible bidders.

The chemical laboratory was installed in the Metal Pavilion, a short distance from the other buildings.

EQUIPMENT.

The plant, when put into operation in September, contained the following testing equipment, all of which had been contributed free of charge:

Two Heine water-tube boilers, 210 horsepower each, contributed by the Heine Safety Boiler Company, of New York and St. Louis.

One Allis Corliss engine, contributed by the Allis-Chalmers Company, of New York and Chicago. The Corliss engine was belt-connected to a Bullock electric generator contributed by the Bullock Electric Manufacturing Company, of Cincinnati, Ohio.

One Frost fire-tube boiler of 100 horsepower and a 50-horsepower slide-valve engine, both contributed by the Frost Engine Company, of Galesburg, Ill.

One Taylor gas producer, with complete outfit for scrubbing and purifying gas, contributed by R. D. Wood & Co., of Philadelphia.

One Westinghouse gas engine, of 235 brake horsepower, furnished by the Westinghouse Machine Company, of Pittsburg, and operated by the gas made in the Taylor producer.

One Westinghouse electric generator, belt-connected to the gas engine, contributed by the Westinghouse Electric and Manufacturing Company, of Pittsburg.

Seven motors of different horsepower, required for the operation of the different portions of the plant, contributed by the Westinghouse Electric and Manufacturing Company.

One Bartlett direct-heat rotating drier for driving out the moisture from washed coals and lignites whose moisture contents were too high to permit successful briquetting, contributed by the C. O. Bartlett & Snow Company, of Cleveland, Ohio.

Two briquetting plants—one exhibited by William Johnson & Sons, of Leeds, England, and one by the American Compressed Fuel Company, of Chicago. In order that the briquetting machine of British manufacture should be installed in conformity with the law, the freight bill was paid by the Western Coal and Mining Company, of St. Louis.

A washing plant equipped with a New Century jig, contributed by the American Concentrator Company, of Joplin, Mo., and a modified Stewart jig, contributed by the Link Belt Machinery Company, of Chicago.

The fire brick and common brick used in the construction of the coke ovens were donated by the Laclede Fire Brick Manufacturing Company, of St. Louis.

The foregoing statement includes all that might properly be considered testing machinery, but the following additional incidental equipment was contributed by the firms mentioned:

One Williams crusher, by the Williams Patent Crusher and Pulverizer Company, of St. Louis.

A complete outfit of belt-conveying apparatus, contributed and installed by the Robins Conveying Belt Company, of New York.

Scales, by Fairbanks, Morse & Co., of New York and Chicago.

Smoke-preventing device, automatic steam jet, by H. H. Hughes, of St. Louis.

Thermometers and pressure gages, by the Hohmann & Maurer Manufacturing Company, of Rochester, N. Y.

Draft gages, by the Appliance Manufacturing Company, of Chicago.

Feed-water heater and pump, by the Stilwell-Bierce Smith-Vaile Company, of Cincinnati, Ohio.

Le Chatelier pyrometers, by Charles Engelhard, of New York.

Engine indicators and attachments, by the Ashcroft Manufacturing Company, of New York, and the Crosby Steam Gage and Valve Company, of Chicago.

Metallic piston packing, by the Steel Mill Packing Company, of Detroit, Mich.

Burroughs adding machine, by the American Arithmometer Company, of St. Louis.

Insulated electric wire, by the American Steel and Wire Company, of Chicago.

Machine and engine oil for lubricating the machinery, and heavy and medium oil for binding material in the manufacture of briquettes from bitiuminous coals and lignites, by the Waters-Pierce Oil Company, of St. Louis.

Oil filter, by the Famous Filter Company, of St. Louis.

Gas meters, by the Pittsburg Meter Company, of Pittsburg.

Dumping car and bucket conveyors, by the Austin Manufacturing Company, of Chicago.

Centrifugal pump, by Henion & Hubbell, of Chicago.

Coal-tar pitch, from the Barrett Manufacturing Company, of New York and elsewhere, and the Chatfield Manufacturing Company, of Cincinnati.

Power crusher and automatic sampler for preparing samples for the chemical laboratory, by the F. W. Braun Company, of Los Angeles, Cal.

Cooking range, by the Buck Stove and Range Company, and a heating stove, by the Bridge & Beach Manufacturing Company, both of St. Louis, for the purpose of testing briquettes for domestic use.

Calculating machine, by the Keuffel & Esser Company, of New York.

The plans for the buildings and their arrangement were prepared by the Roberts & Shaefer Company, engineers, of Chicago. The construction work was done under the supervision of Mr. Bert Fankboner, one of the engineers for the Roberts & Shaefer Company. Mr. Fankboner was accidentally killed by an electric locomotive early in October, just as the plant had been placed in successful operation and when he could have enjoyed the results of his hard and conscientious labor.

The boiler room was thoroughly equipped with standardized apparatus for weighing coal and water, for determining the force of th

draft, for ascertaining the temperatures in the different parts of the furnace, and for analyzing the flue gases. The gas producer and gas engine were also provided with apparatus for ascertaining temperatures, for collecting samples of the gas as produced, and for determining the horsepower developed in the gas engine. The electric horsepower developed by both the steam engine and the gas engine was ascertained by twenty-minute readings of voltmeters and ammeters, and the electrical horsepower developed per pound of fuel consumed by the two different methods was thus accurately determined and recorded.

The chemical laboratory was equipped with every necessary apparatus and chemical material for making proximate and ultimate analyses and for determining the calorific value of the coal. The last was determined by a Mahler bomb calorimeter, and the observations were made in a room especially set aside for this purpose.

The railroad companies entering St. Louis or having coal resources along their lines have cooperated most heartily with the committee in charge of the work.

PERSONNEL.

The various portions of the plant were put under the direction of men thoroughly equipped in their special lines. The steam test division was under the direction of Prof. L. P. Breckenridge, of the University of Illinois, with Prof. D. T. Randall, of the same university, as chief assistant. The gas-producer tests were under the direction of Prof. Robert H. Fernald, of Washington University, St. Louis, assisted by Capt. John A. Laird, also of St. Louis. The operation of the gas producer was directed by Messrs. Charles W. Lummis and C. O. Nordenson, expert engineers, of R. D. Wood & Co., of Philadelphia. The gas-engine operations were looked after by Mr. J. G. Culbertson, an engineer of the Westinghouse Company. The washing operations were under the superintendence of Mr. John D. Wick, of Chicago, general foreman of the plant. The coking plant was in charge of Mr. Fred. W. Stammler, of Johnstown, Pa., assisted by Mr. B. B. Boyd, of Uniontown, Pa. The briquetting tests were directed by Dr. Joseph Hyde Pratt, of the University of North Carolina and the North Carolina Geological Survey, assisted by Mr. A. A. Steel. The plans for the chemical laboratory, its equipment and operations, were under the direction of Prof. N. W. Lord, of the Ohio State University. His chief assistant at the coal-testing plant was Mr. E. E. Somermeier, who is also his chief assistant in his university work. The engine room was in charge of Mr. Otto Kinner, a mechanical engineer, of St. Louis, and the electrical apparatus was looked after by Mr. Jos. Underwood, also of St. Louis. Mr. Louis H. Legler, of Indiana, rendered valuable service as timekeeper and general assistant foreman of the plant.

FIELD WORK.

The field work was placed in charge of Mr. M. R. Campbell, one of the committee appointed by the Director of the Survey for the prosecution of these tests, who was assisted throughout the field season by J. Shober Burrows and John W. Groves, and for a short time by Frank W. De Wolf. All of the coal shipped to the plant for testing, with the exception of a few carloads, was collected under the supervision of one of these Survey officials. This was done to avoid any possibility of the criticism that selected coals had been subjected to these tests.

SAMPLING.

When the coal was shipped the Survey representative sampled it at two working faces of the mine, and the samples so obtained were shipped to the chemical laboratory for analysis. When the car was unloaded at the testing plant, what is known as a "laboratory car sample," consisting of about 200 pounds of coal, was taken from every car and sent to the laboratory, where the coal was pulverized, quartered down, and analyzed. Again, as the coal was distributed to different portions of the plant for testing, other samples were taken in a regular and uniform manner and sent to the laboratory for analysis. Such a series of coal analyses has never before been made in this country.

REPORTS.

The preliminary reports of the operations of the different portions of the plant have been prepared by the experts in charge. A more detailed report, which will be fully illustrated by photographs, graphic charts, etc., and which will give the methods employed and results obtained in much greater detail, is in preparation, and will be published at the earliest possible date.

RESULTS.

It will be necessary to test a larger number and greater variety of coals and lignites, and to repeat with greater care some of the tests already made, before a full discussion of the results of these investigations can be properly entered upon or their value fully appreciated. But the results already obtained from the preliminary investigations made during the last six months are sufficient to indicate their far-reaching importance in the solution of the fuel and power problems upon which the varied industries of the country depend.

Among the results already clearly indicated by these preliminary tests the following may be stated as worthy of special consideration:

(1) The tests in the steam-boiler plant of 65 carload samples of coal from 17 States indicate the high steam-producing capacity of American

coals, and that the quality of many of these coals may be improved by washing.

(2) Most of the American bituminous coals and lignites can be used as a source of power in a gas-producer plant.

(3) As indicated by comparative tests of 14 bituminous coals from 9 States, the power efficiency of these coals when used in the gas-producer plant is two and one-half times greater than their efficiency when used in the steam-boiler plant; or, in other words, 1 ton of these coals used in the gas-producer plant has developed, on a commercial scale, as much power as $2\frac{1}{2}$ tons of the same coal when used in the ordinary steam-boiler plant.

(4) Some of the lignites from undeveloped but extensive deposits in North Dakota and Texas, when tested in the gas producer and gas engine, have shown unexpectedly high power-producing qualities, such as promise large future developments in those and other States.

(5) Some of the American coals, and the "slack" produced in mining these coals, can be briquetted on a commercial basis.

The value of the results of these investigations is, of course, not limited to the coal-producing sections of the country, but extends through every State and Territory where coal or other mineral fuel is used as a source of power. Thus, in the New England States no coal is mined; but in the year 1900 the steam power produced through the consumption of coal and used for manufacturing purposes in these States cost approximately $50,000,000. The development of this power through the more efficient methods suggested by these investigations would mean a saving to the manufacturers in these States of $15,000,000 to $20,000,000 per annum.

As another illustration of the way these investigations may influence the affairs of the nation as a whole, it may be stated that there were used in the naval vessels of the United States in 1903 approximately 500,000 tons of coal, costing $2,500,000. If the future gas producer and gas engine can be substituted on our battle ships and cruisers for the existing steam boilers and engines, the saving in the cost of coal would be not less than $1,000,000 per annum, or, what would be of far greater importance, the distances traversed by each ship without coaling would be more than doubled.

The fact that the coals and other mineral fuels used in the United States during 1904 cost the consumers approximately $1,500,000,000 indicates the magnitude and importance of the problems under investigation by the Geological Survey in connection with its coal-testing plant.

FIELD WORK.

By Marius R. Campbell.

INTRODUCTION.

The writer was assisted in the collection of coal for testing purposes throughout the field season by Mr. J. Shober Burrows and Mr. John W. Groves, and for a short time by Mr. Frank W. De Wolf.

In a circular letter sent out early in the season the coal operators of the United States were invited to participate in these tests, upon the conditions stated in the act of Congress under which the work was carried on, namely, that all material to be tested should be delivered at the testing plant free of cost to the Government. It was decided by the committee in charge that for practical tests of the character contemplated not less than one carload of coal should be accepted. In response to this invitation offers of coal were made from almost every coal-producing State in the Union. From these offers it was decided to acept such samples as best represented the State from which they were obtained, and also the various fields or districts within the State. Owing, however, to the fact that the testing plant was put in operation late in the season, it was found to be impossible to test all of the coal samples offered, and so a number of important coal fields and even States of large production are not represented.

It is a generally recognized principle that the value of tests upon fuel and similar materials depends largely upon the way in which the sample was obtained and what it represents. In the present work the committee in charge decided to give this feature special attention and in every case possible to superintend the collection of the sample, so as to be in a position to guarantee that the coal tested fairly represented the coal produced from the mine as far as it is possible for one carload to represent the output of a mine.

CAR SAMPLES.

In actual operation the sampling was done as follows:

After arrangements had been made for the coal, and its transportation was assured, the representative of the testing plant visited the mine for the purpose of procuring a sample. He first entered the mine and carefully studied the character of the coal as shown in the

bed before it was mined, and the method of mining and of cleaning the coal as it was loaded on cars in the mine. After becoming familiar with the underground conditions, he visited the tipple and observed the manner of handling the coal for market, getting information regarding the arrangement of the screens, the grades of coal produced, and the method of utilizing slack coal, washing, coking, etc. When this was accomplished the inspector supervised the loading of a car for testing purposes, selecting run-of-mine, lump, or nut coal, as seemed to him most nearly representative of the general output of the mine, or in particular cases selecting certain grades for special tests. The loading of the car was carefully watched so as to prevent undue picking or any irregularity that would tend to make the test sample better or worse than the average output.

In certain cases where a number of cars were in the yards, already loaded with what was regarded as representative coal, one of these cars was selected at random and shipped to the testing plant.

In case the car sample consisted of lignite or soft bituminous coal such as probably would be affected by weathering in transit, it was loaded in a box car, but the great majority of samples were shipped in ordinary open coal cars without any protection from the weather. Most of this coal was shipped during the months of August, September, October, and November, and these months were unusually dry in the vicinity of St. Louis. For this reason it seems probable that the coal in transit was subjected to little rain or snow, and that the principal change caused by weather was a change in amount of moisture due to atmospheric conditions which probably affected not only the coal in open cars but also that shipped in box cars.

MINE SAMPLES.

As an additional check on the quality of the coal, and especially for the determination of its moisture content in its native condition, two samples were taken in each mine for chemical analysis. These were handled as follows: After a general inspection of the mine to determine the variations of the coal in thickness and quality, two points were selected in opposite or widely separated parts of the mine, and after the face of the coal was cleaned of any weathered coal or powder smoke, a cut was made across the face of the coal from roof to floor, including all of the benches of coal mined and such impurities as were not removed in ordinary work. This cut was about 3 inches wide and 1 inch deep. The coal obtained from it, amounting to 25 or 30 pounds, was caught upon an oilcloth blanket spread upon the floor of the mine so as to protect the sample from water and from including any shale or clay fragments.

The coal composing the sample was then pulverized and quartered down according to the generally accepted rules for preparing samples

until a quart sample was obtained with the particles of coal reduced to a size not much greater than one-fourth inch in diameter. The sample was placed in an air-tight galvanized iron can having a screw top and the can was hermetically sealed by screwing the top down tight and covering the joint with tire tape. The can containing the sample was then mailed to the testing plant, and in almost all cases it reached its destination within two or three days of the date of sampling in the mine. When the can reached the chemical laboratory the sample was at once transferred to a Mason glass jar, in which it was sealed until the time for taking it up for chemical analysis.

UNINSPECTED CAR SAMPLES.

In a few cases carload samples were shipped to the testing plant without the personal supervision of a representative of the Government. In one case this was the result of a misunderstanding; in others the sample consisted of slack coal, and its selection did not need personal supervision. In the case of the North Dakota lignite, it was impossible to send a man there early enough in the season to insure the car reaching the plant before the close of the Exposition period. This necessitated the loading of a sample without supervision, but since it is probable that the lignite from these mines is of fairly uniform quality, the sample was accepted as representative.

The committee in charge do not care to hold themselves responsible for the representative character of coal thus sent in without their personal supervision, but the results of the tests are given for what they are worth.

The samples sent in irregularly are as follows:

Indian Territory No. 6.—Slack coal from mine of the Southwestern Development Company, located at Coalgate, Ind. T. This sample represented the waste product of the mine, and consequently its selection did not need to be under the supervision of a representative of the testing plant.

Kansas No. 4.—Lump coal from mine of the Atchison Coal Mining Company, located near Atchison, Kans. Owing to misunderstanding of instructions this sample was sent without personal supervision, but its representative character is vouched for by Prof. Erasmus Haworth, State geologist of Kansas.

Montana No. 1.—Washed slack from Red Lodge, Mont. This is a lignitic coal which was sent in by Mr. L. S. Storrs, geologist in charge of coal lands of the Northern Pacific Railway Company.

North Dakota No. 1.—Brown lignite from Lehigh, N. Dak. Sent by L. S. Storrs.

North Dakota No. 2.—Brown lignite from mine of the Cedar Coulee Coal Company, located 4 miles southeast of Williston, N. Dak. This

sample was sent to the testing plant by Mr. H. A. Storrs, engineer, Reclamation Service, Denver, Colo.

Pennsylvania Nos. 1 and 2.—Lump coal from Eureka No. 31 mine, of the Berwind-White Coal Mining Company, located at Windber, Somerset County, Pa. This coal was used in preliminary tests to show that the machinery was in proper working order. The tests were satisfactory, but the assumption that the coal tested was representative in character rests upon the statement of the company furnishing it.

Pennsylvania No. 3.—Anthracite culm from Pennsylvania Coal Company, Scranton, Pa. This sample of culm was sent for briquetting purposes and hence needed no inspection.

DESCRIPTION OF CAR SAMPLES.

Sixty-five car samples of coal were received at the testing plant during the season, from seventeen States. These may be grouped by States as follows:

Alabama, 2; Arkansas, 6; Colorado, 1; Illinois, 6; Indiana, 2; Indian Territory, 6; Iowa, 5; Kansas, 5; Kentucky, 4; Missouri, 4; Montana, 1; New Mexico, 2; North Dakota, 2; Pennsylvania, 3; Texas, 2; West Virginia, 12; Wyoming, 2.

The following is a complete list of the car samples received, giving details of ownership, location, character of sample, etc.:

List of car samples

Name of sample.	Operator.	Mine.	Location.	Railroad.
Alabama 1......	Ivy Coal and Iron Co...	No. 8..........	1½ miles west of Horse Creek, Walker County, Ala.	Frisco System ....
Alabama 2......	Galloway Coal Co., Carbon Hill, Ala.	No. 5..........	About ¾ mile northwest of Carbon Hill, Walker County, Ala.	Frisco System ....
Arkansas 1......	Central Coal and Coke Co., Kansas City, Mo.	No. 3..........	Huntington, Sebastian County, Ark.	Frisco System ....
Arkansas 2......	Central Coal and Coke Co., Kansas City, Mo.	No. 12.........	Bonanza, Sebastian County, Ark.	Frisco System ....
Arkansas 3......	Western Coal and Mining Co., St. Louis, Mo.	No. 18	Jenny Lind, Sebastian County, Ark.	Missouri Pacific Railroad.
Arkansas 4......	Western Coal and Mining Co., St. Louis, Mo.	No. 18	Denning, Franklin County, Ark.	Missouri Pacific Railroad.
Arkansas 5......	Western Coal and Mining Co., St. Louis, Mo.	No. 4	West of Coal Hill, Franklin County, Ark.	Missouri Pacific Railroad.
Arkansas 6......	Western Coal and Mining Co., St. Louis, Mo.	No. 18	Jenny Lind, Sebastian County, Ark.	Missouri Pacific Railroad.
Colorado 1......	Northern Coal and Coke Co., Denver, Colo.	Simpson......	Lafayette, Boulder County, Colo.	Colorado and Southern Railroad, Burlington System.
Illinois 1........	Western Anthracite Coal and Coke Co., St. Louis, Mo.	No. 1..........	O'Fallon, St. Clair County, Ill.	Belt Terminal R. R. of East St. Louis.
Illinois 2........	Western Anthracite Coal and Coke Co., St. Louis, Mo.	No. 1..........	O'Fallon, St. Clair County, Ill.	Belt Terminal R. R. of East St. Louis.
Illinois 3........	Southern Illinois Coal Mining and Washing Co., Marion, Ill.	No. 3..........	Marion, Williamson County, Ill.	Chicago and Eastern Illinois R. R.
Illinois 4........	Donk Bros. Coal and Coke Co., St. Louis, Mo.	No. 3..........	About 1 mile west of Troy, Madison County, Ill.	St. Louis, Troy and Eastern R. R.
Illinois 5........	Donk Bros. Coal and Coke Co., St. Louis, Mo.	No. 1..........	Collinsville, Madison County, Ill.	St. Louis, Troy and Eastern R. R.
Illinois 6........	Clover Leaf Coal Co., Coffeen, Ill.	No. 1 shaft....	Coffeen, Ill	Toledo, St. Louis and Western R. R.

received at testing plant.

Sampler.	Kind of coal.	Name of bed.	Tests.
M. R. Campbell	Bituminous. Over 1-inch screen.	Horse Creek	Steam test, p. 80. Washing test, p. 66. Coking test, p. 121. Briquetting test, p. 148.
M. R. Campbell	Bituminous. Through 8-inch and over $\frac{3}{4}$-inch screen, also washed slack.	Jagger	Steam test, p. 80. Producer gas test, p. 88. Coking test, p. 122.
M. R. Campbell	Bituminous. Over $1\frac{1}{8}$-inch screen.	Huntington	Steam test, p. 80. Coking test, p. 122. Briquetting test, p. 148.
M. R. Campbell	Bituminous. Over $1\frac{1}{8}$-inch screen.	Jenny Lind	Steam test, p. 80. Coking test, p. 122. Briquetting test, p. 148.
J. W. Groves	Bituminous. Over $1\frac{1}{8}$-inch screen.	Jenny Lind	Steam test, p. 80. Coking test, p. 122. Briquetting test, p. 149.
Shipped by operator	Semibituminous. Slack	Denning	Steam test, p. 80. Briquetting test, p. 149.
J. W. Groves	Semibituminous. Half lump, half slack.	Denning	Steam test, p. 80. Briquetting test, p. 151.
J. W. Groves	Bituminous. Slack coal	Jenny Lind	Washing test, p. 66. Coking test, p. 122. Briquetting test, p. 152.
F. W. De Wolf	Black lignite. Run of mine.		Steam test, p. 80. Producer gas test, p. 90. Briquetting test, p. 152.
M. R. Campbell	Bituminous. Over 1-inch screen.	No. 8 ?	Steam test, p. 80. Coking test, p. 122. Briquetting test, p. 153.
M. R. Campbell	Bituminous. Slack	No. 8 ?	Steam test, p. 80. Washing test, p. 61. Coking test, p. 123.
J. W. Groves	Bituminous. Run of mine.	No. 7	Steam test, p. 80. Producer-gas test, p. 91. Washing test, p. 66. Coking test, p. 123.
M. R. Campbell	Bituminous. Over 2-inch screen.		Steam test, p. 80. Producer-gas test, p. 93. Briquetting test, p. 153.
M. R. Campbell	Bituminous. Slack		Washing test, p. 67. Coking test, p. 123.
J. S. Burrows	Bituminous. Run of mine.	No. 5	Steam test, p. 80.

List of car samples received

Name of sample.	Operator.	Mine.	Location.	Railroad.
Indiana 1	J. Woolley Coal Co., Evansville, Ind.	Mildred	Mildred, Sullivan County, Ind.	Evansville and Terre Haute R. R.
Indiana 2	T. D. Scales Coal Co., Boonville, Ind.	Electric	Boonville, Warrick County, Ind.	Southern Rwy
Indian Territory 1.	Whitehead Coal and Mining Co., Henryetta, Ind. T.	No. 1	Henryetta, Ind. T.	Frisco System
Indian Territory 2.	Rock Island Coal Co., Hartshorne, Ind T.	No. 8	Hartshorne, Ind. T.	Rock Island System.
Indian Territory 3.	D. Edwards & Son, Edwards, Ind. T.	No. 1	Edwards, Ind. T.	Rock Island System.
Indian Territory 4.	Western Coal and Mining Co., St. Louis, Mo.	No. 5	Half mile north of Lehigh, Ind. T.	Missouri, Kansas and Texas Rwy.
Indian Territory 5.	Western Coal and Mining Co., St. Louis, Mo.	No. 7	Lehigh, Ind. T.	Missouri, Kansas and Texas Rwy.
Indian Territory 6.	Southwestern Development Co., Parsons, Kans.		Colgate, Ind. T.	Missouri, Kansas and Texas Rwy.
Iowa 1	Anchor Coal Co., Ottumwa, Iowa.	No. 2	Laddsdale, Iowa	Rock Island System.
Iowa 2	Mammoth Vein Coal Co., Hamilton, Iowa.	No. 5	Liberty Township, Marion County, Iowa.	Wabash Railroad.
Iowa 3	Gibson Coal Mining Co., Des Moines, Iowa.	No. 4	Near Altoona, Polk County, Iowa.	Rock Island System.
Iowa 4	Centerville Block Coal Co., Centerville, Iowa.	No. 3	Centerville, Appanoose County, Iowa.	C., B. & Q. R. R.; I. C. R. R.; C., R. I. & P. R. R.; C., M. & St. P. R. R.;
Iowa 5	Inland Fuel Co., Chariton, Iowa.	No. 1	Chariton, Lucas County, Iowa.	Burlington System, within 6 miles.
Kansas 1	Western Coal and Mining Co., St. Louis, Mo.	No. 10	Fleming, Crawford County, Kans.	Missouri Pacific R. R.
Kansas 2	Western Coal and Mining Co., St. Louis, Mo.	No. 11	Yale, Crawford County, Kans.	Missouri Pacific R. R.
Kansas 3	Southern Coal and Mercantile Co., Scammon, Kans.	No. 9	Scammon, Cherokee County, Kans.	Frisco System

at testing plant—Continued.

Sampler.	Kind of coal.	Name of bed.	Tests.
J. S. Burrows	Bituminous. Run of mine.	No. 6	Steam test, p. 80. Producer-gas test, p. 94. Washing test, p. 63. Coking test, p. 123. Briquetting test, p. 154.
J. S. Burrows	Bituminous. Run of mine.	No. 5	Steam test, p. 81. Producer-gas test, p. 96. Briquetting test, p. 154.
J. S. Burrows	Bituminous. Over 1¾-inch screen.	Henryetta	Steam test, p. 81. Producer-gas test, p. 98. Coking test, p. 123.
J. W. Groves	Bituminous. Run of mine.	Hartshorne	Steam test, p. 81. Washing test, p. 67. Coking test, p. 124. Briquetting test, p. 155.
J. W. Groves	Bituminous. Run of mine.	McAlester	Steam test, p. 81. Washing test, p. 68. Coking test, p. 124. Briquetting test, p. 155.
J. W. Groves	Bituminous. Over 1-inch screen.	Lehigh	Steam test, p. 81.
J. W. Groves	Bituminous. Mixed through ¼ and ½ inch screen.	Lehigh	Washing test, p. 68. Coking test, p. 124.
Shipped by operator	Bituminous. Slack	Lehigh	Briquetting test, p. 155.
J. W. Groves	Bituminous. Over 1¼-inch screen.	Middle bed	Steam test, p. 81. Washing test, p. 68. Coking test, p. 124.
J. W. Groves	Bituminous. Run of mine.	Big vein	Steam test, p. 81. Washing test, p. 69. Coking test, p. 124.
J. W. Groves	Bituminous. Over 1⅝-inch screen.	Third seam	Steam test, p. 81. Washing test, p. 69. Coking test, p. 125.
J. W. Groves	Bituminous. Over 1⅝-inch screen.	Lower bed	Steam test, p. 81. Washing test, p. 69. Coking test, p. 125. Briquetting test, p. 158.
J. W. Groves	Bituminous. Run of mine.	Lower bed	Steam test, p. 81. Washing test, p. 70. Coking test, p. 125.
J. W. Groves	Bituminous. Run of mine.	Weir-Pittsburg	Steam test, p. 81. Coking test, p. 125.
J. S. Burrows	Bituminous. Lump and nut.	Weir-Pittsburg	Steam test, p. 81. Coking test, p. 125. Briquetting test, p. 159.
M. R. Campbell	Bituminous. Run of mine.	Weir-Pittsburg	Steam test, p. 81. Coking test, p. 125.

List of car samples received

Name of sample.	Operator.	Mine.	Location.	Railroad.
Kansas 4	The Atchison Coal Mining Co., Atchison, Kans.	Atchison	1½ miles below Atchison, Atchison County, Kans.	Missouri Pacific R. R.
Kansas 5	Southwestern Development Co., Parsons, Kans.	No. 11	West Mineral, Kans.	Missouri, Kansas and Texas R. R.
Kentucky 1	National Coal and Iron Co., Louisville, Ky.	Straight Creek No. 2.	Straight Creek, Bell County, Ky.	Louisville and Nashville R. R.
Kentucky 2	St. Bernard Mining Co., Earlington, Ky.	No. 11	Earlington, Hopkins County, Ky.	Louisville and Nashville R. R.
Kentucky 3	St. Bernard Mining Co., Earlington, Ky.	Barnsley	Barnsley, Hopkins County, Ky.	Louisville and Nashville R. R.
Kentucky 4	Wheatcroft Coal and Mining Co., Wheatcroft, Ky.	Wheatcroft	Wheatcroft, Webster County, Ky.	Illinois Central R. R.
Missouri 1	New Home Coal Co., Sprague, Mo.	No. 1	New Home, Bates County, Mo.	Frisco System
Missouri 2	Northwestern Coal and Mining Co., Kansas City, Mo.	No. 8	1 mile south of Bevier, Macon County, Mo.	Burlington System.
Missouri 3	Mendota Coal and Mining Co., Mendota, Mo.		Mendota, Putnam County, Mo.	Burlington System.
Missouri 4	Morgan County Coal Co., St. Louis, Mo.		Near Barnett, Morgan County, Mo.	Rock Island System.
Montana 1			Red Lodge, Carbon County, Mont.	Northern Pacific R. R.
New Mexico 1	American Fuel Co., Denver, Colo.	Weaver	3 miles north of Gallup, McKinley County, N. Mex.	Santa Fe R. R
New Mexico 2	Caledonian Coal Co., Gallup, N. Mex.	Otero	1½ miles east of Gallup, McKinley County, N. Mex.	Santa Fe R. R
North Dakota 1			Lehigh, Stark County, N. Dak.	Northern Pacific R. R.
North Dakota 2	Cedar Coulee Coal Co., Williston, N. Dak.		4 miles southeast of Williston, Williams County, N. Dak.	Great Northern R. R.
Pennsylvania 1	Berwind-White Coal Mining Co., Philadelphia, Pa.	Eureka 31	Windber, Somerset County, Pa.	Pennsylvania R. R
Pennsylvania 2	Berwind-White Coal Mining Co., Philadelphia, Pa.	Eureka 31	Windber, Somerset County, Pa.	Pennsylvania R. R

at testing plant—Continued.

Sampler.	Kind of coal.	Name of bed.	Tests.
Shipped by operator..	Bituminous	....	Steam test, p. 81. Coking test, p. 125.
M. R. Campbell	Bituminous. Over $\frac{3}{8}$-inch screen.	Weir-Pittsburg ...	Steam test, p. 81.
J. S. Burrows..........	Bituminous. Run of mine.	....	Steam test, p. 81. Coking test, p. 126. Briquetting test, p. 159.
J. S. Burrows..........	Bituminous. Over $\frac{7}{8}$-inch screen.	No. 11	Steam test, p. 81. Coking test, p. 126. Briquetting test, p. 159.
J. S. Burrows..........	Bituminous. Run of mine and coal over $\frac{7}{8}$-inch screen.	No. 9	Steam test, p. 81. Producer-gas test, p. 99. Washing test, p. 70. Coking test, p. 126.
J. S. Burrows..........	Bituminous. Run of mine.	No. 11.............	Steam test, p. 81. Washing test, p. 70. Coking test, p. 126.
J. S. Burrows..........	Bituminous. Run of mine.	....	Steam test, p. 81. Briquetting test, p. 160.
J. W. Groves..........	Bituminous. Run of mine.	Bevier............	Steam test, p. 81. Producer gas test, p. 101. Washing test, p. 70. Coking test, p. 126.
Shipped by operator..	Bituminous slack..........	....	Steam test, p. 82. Washing test, p. 64. Coking test, p. 126.
J. W. Groves..........	Bituminous. Run of mine.	....	Steam test, p. 82. Coking test, p. 126.
Shipped by L. S. Storrs	Black lignite (?) No. 4, washed nut.	....	Producer gas test, p. 102. Briquetting test, p. 160.
M. R. Campbell.......	Black lignite. Run of mine	No. 3 and No. $3\frac{1}{2}$..	Steam test, p. 82. Briquetting test, p. 161.
M. R. Campbell.......	Black lignite. Slack	Otero, Thatcher, Crownpoint.	Steam test, p. 82. Briquetting test, p. 162.
Shipped by L. S. Storrs	Brown lignite	....	Steam test, p. 82. Briquetting test, p. 162.
Shipped by operator..	Brown lignite.............	....	Producer-gas test, p. 104.
Shipped by operator..	Bituminous...............	B (?)..............	Steam test, p. 82.
Shipped by operator..	Bituminous...............	B (?)..............	Steam test, p. 82.

List of car sample received

Name of sample.	Operator.	Mine.	Location.	Railroad.
Pennsylvania 3.	Pennsylvania Coal Co., Scranton, Pa.	....	....	....
Texas 1.........	Houston County Coal and Manufacturing Co., Crockett, Tex.	Wootters	11 miles south of Crockett, Houston County, Tex.	International and Great Northern R. R.
Texas 2.........	Consumers Lignite Co., Dallas, Tex.	....	Hoyt, Wood County, Tex.	Texas Short Line, M., K. & T. R. R.
West Virginia 1.	Virginia and Pittsburg Coal and Coke Co., New York, N. Y.	Kingmont....	Kingmont, Marion County, W. Va.	Baltimore and Ohio R. R.
West Virginia 2.	Pitcairn Coal Co., Clarksburg, W. Va.	Pitcairn	Clarksburg, Harrison County, W. Va.	Baltimore and Ohio R. R.
West Virginia 3.	West Virginia Coal Co., Morgantown, W. Va.	Richard	4 miles southeast of Morgantown, Monongalia County, W. Va.	Morgantown and Kingwood R. R.
West Virginia 4.	West Virginia Coal Co., Morgantown, W. Va.	Bretz	4 miles northwest of Kingwood, Preston County, W. Va.	Morgantown and Kingwood R. R.
West Virginia 5.	Davis Colliery Co., Elkins, W. Va.	Coalton.......	Coalton, Randolph County, W. Va.	Coal and Coke R. R.
West Virginia 6.	The New River Smokeless Coal Co., Rush Run, W. Va.	Rush Run	Rush Run, Fayette County, W. Va.	Chesapeake and Ohio R. R.
West Virginia 7.	The New River Smokeless Coal Co., Rush Run, W. Va.	Sun No. 1.....	Sun, Fayette County, W. Va.	Chesapeake and Ohio R. R.
West Virginia 8.	The Gauley Mountain Coal Co., Ansted, W. Va.	Gauley Mountain.	Ansted, Fayette County, W. Va.	Chesapeake and Ohio R. R.
West Virginia 9.	Mount Carbon Coal Co., (Limited), Powellton, W. Va.	Vulcan	1 mile above Powellton, Fayette County, W. Va.	Chesapeake and Ohio R. R.
West Virginia 10	Stuart M. Buck, Bramwell, W. Va.	Experimental mine.	Mora, Mercer County, W. Va.	Norfolk and Western R. R.
West Virginia 11	W. H. Coffman, Bluefield, W. Va.	Zenith 1 and 2.	Zenith, McDowell County, W. Va.	Norfolk and Western R. R.
West Virginia 12.	Big Sandy Coal and Coke Co., Marytown, W. Va.	Big Sandy....	Big Sandy, McDowell County, W. Va.	Norfolk and Western Railroad.
Wyoming 1.....	Wyoming Coal Mining Co., Monarch, Wyo.	Monarch	9 miles northwest of Sheridan, Sheridan County, Wyo.	Burlington System.
Wyoming 2.....	Cambria Fuel Co., Cambria, Wyo.	Antelope 1 and 2 and Jumbo.	Cambria, Weston County, Wyo.	Burlington System.

at testing plant—Continued.

Sampler.	Kind of coal.	Name of bed.	Tests.
Shipped by operator..	Anthracite. Culm	....	Steam test, p. 82. Briquetting test, p. 163.
M. R. Campbell.......	Brown lignite.............	....	Producer-gas test, p. 106.
M. R. Campbell.......	Brown lignite.............	....	Producer-gas test, p. 107.
J. S. Burrows.........	Bituminous. Run of mine.	Pittsburg	Steam test, p. 82. Producer-gas test, p. 109. Coking test, p. 126.
J. S. Burrows.........	Bituminous. Run of mine.	Pittsburg	Steam test, p. 82. Washing test, p. 71. Coking test, p. 127.
J. S. Burrows..........	Bituminous. Run of mine.	Upper Freeport...	Steam test, p. 82. Washing test, p. 71. Coking test, p. 127. Briquetting test, p. 165.
J. S. Burrows..........	Bituminous. Run of mine.	Upper Freeport...	Steam test, p. 82. Producer-gas test, p. 111. Washing test, p. 71. Coking test, p. 127.
J. S. Burrows..........	Bituminous. Over $1\frac{1}{4}$ inch screen.	Upper Freeport...	Steam test, p. 82. Washing test, p. 72. Coking test, p. 127.
J. S. Burrows..........	Bituminous. Run of mine.	Quinnimont......	Steam test, p. 82. Coking test, p. 128. Briquetting test, p. 165.
J. S. Burrows..........	Bituminous. Run of mine.	Sewall............	Steam test, p. 82. Coking test, p. 128.
J. S. Burrows..........	Bituminous. Run of mine.	Ansted	Steam test, p. 82. Coking test, p. 128.
J. S. Burrows..........	Bituminous. Run of mine.	Powellton	Steam test, p. 82. Producer-gas test, p. 112. Washing test, p. 72. Coking test, p. 128.
J. S. Burrows..........	Bituminous. Over $\frac{3}{8}$-inch screen.	No. 6 (?)	Steam test, p. 83. Coking test, p. 128.
J. S. Burrows..........	Bituminous. Run of mine.	Pocahontas.......	Steam test, p. 83. Coking test, p. 129.
J. S. Burrows..........	Bituminous. Run of mine.	No. 8..............	Steam test, p. 83. Producer-gas test, p. 114. Washing test, p. 72. Coking test, p. 129.
F. W. De Wolf	Bituminous. Over 5-inch screen.	....	Steam test, p. 83. Briquetting test, p. 165.
F. W. De Wolf	Bituminous. Run of mine	....	Steam test, p. 83. Producer-gas test, p. 115.

WORK OF THE CHEMICAL LABORATORY.

By N. W. Lord.

INTRODUCTION.

In this preliminary report only the mine samples and the laboratory car samples of the coals are considered.

Numerous analyses made in connection with steam tests, producer-gas tests, coking tests, etc., representing the portions of coal used in these tests, are published in the several reports giving the results of the tests and are not repeated here.

SAMPLING.

The mine samples were taken by the agents of the Survey at the mines from which the coal was shipped and were sent to the laboratory in sealed cans. They were taken on opposite sides of the mine or in places widely separated, so that to a certain extent they show the variations in the quality of the coal within the limits of the mine. In the final report the points at which the samples were obtained will be accurately described, but in the present report the samples will be designated merely "mine sample A" and "mine sample B."

The laboratory car samples were taken from the carload of coal sent to the plant for testing at the time that it was unloaded. They usually represent either the whole car or that portion of it used in the tests. The laboratory car sample was obtained after the coal had been passed through rolls having an aperture of about 1¼ inches, by taking portions at short intervals from the buckets of the conveyor. These portions, after thorough mixing, were used for the preparation of the laboratory sample.

LOSS ON AIR DRYING.

Most coals rapidly lose moisture on exposure to air. In grinding the large sample down to the fine state of pulverization necessary in the small laboratory sample there is liable to be a large and undetermined loss of moisture. To reduce the error due to this loss of

moisture, each sample of coal, after a rapid preliminary crushing to about one-fourth inch size and reduction in bulk by quartering where desirable, was weighed and then exposed to the air for about twenty-four hours, or until the loss of weight on further exposure became slight.

The loss of weight thus determined constitutes the "loss on air drying." The coal in this air-dried condition was then pulverized for the final sample to be used in the various operations of the laboratory.

The reduction of the actual results obtained upon the air-dried sample to the equivalent results on the original sample before air drying was accomplished as follows: Each of the results upon the air-dried sample was multiplied by the fraction the air-dried coal formed of the original coal and then (in the proximate analyses) the percentage loss on air drying was added to the figure for moisture so obtained.

In the case of an ultimate analysis the figures so obtained for the oxygen and the hydrogen were each increased by amounts equivalent to the oxygen and hydrogen represented by the loss on air drying when considered as water.

METHODS OF ANALYSIS.

The methods of analysis were essentially those recommended by the committee of the American Chemical Society. The moisture was determined by drying the weighed sample for one hour in an air bath at 105° C. The calorific value was determined in the Mahler bomb calorimeter. The actual value of the result in the calorimeter was corrected for the sulphuric acid formed in the bomb.

In calculating the calorific value from the ultimate analysis the calorific values of hydrogen, carbon, and sulphur were taken as, respectively, 34,460, 8,080, and 2,250 calories.

PERSONNEL.

Mr. E. E. Somermeier, of the department of metallurgy of the Ohio State University, was chief chemist and had immediate charge of the laboratory at the testing plant. The assistant chemists employed in the laboratory were Mr. F. M. Stanton, Mr. John H. Crawford, jr., and Mr. G. A. Burrell. Mr. F. A. Bryan was employed in collecting the car samples and washery samples at the plant.

ANALYSES OF MINE AND LABORATORY CAR SAMPLES.

The following table gives in a condensed form the analyses of "mine" and "laboratory car" samples arranged according to States:

Analyses of mine and laboratory car samples of coal.

	Alabama No. 1.			Alabama No 2.		
	Mine sample B.	Mine sample A.	Laboratory car sample.	Mine sample A.	Mine sample B.	Laboratory car sample.
Laboratory sample No	1077	1078	1201	1075	1076	1225
Loss of moisture on air drying	....	....	0.80	....	....	0.80
Analysis of air-dried sample.						
Proximate: Moisture	....	....	1.55	....	....	2.58
Proximate: Volatile matter	....	....	32.10	....	....	33.15
Proximate: Fixed carbon	....	....	53.71	....	....	51.74
Proximate / Ultimate: Ash	....	....	12.64	....	....	12.53
Ultimate: Sulphur	....	....	0.73	....	....	1.02
Ultimate: Hydrogen	....	....	4.96	....	....	4.79
Ultimate: Carbon	....	....	72.16	....	....	69.24
Ultimate: Nitrogen	....	....	1.66	....	....	1.55
Ultimate: Oxygen	....	....	7.85	....	....	10.87
Calorific value determined:						
Calories	....	....	7,199	....	....	6,916
British thermal units	....	....	12,958	....	....	12,449
Calorific value calculated from ultimate analysis:						
Calories	....	....	7,218	....	....	6,799
British thermal units	....	....	12,992	....	....	12,238
Analysis corrected to sample as received.						
Proximate: Moisture	1.22	1.35	2.34	2.25	2.42	3.36
Proximate: Volatile matter	31.53	31.67	31.84	35.70	34.83	32.86
Proximate: Fixed carbon	54.44	53.35	53.28	53.01	51.62	51.33
Proximate / Ultimate: Ash	12.81	13.63	12.54	9.04	11.13	12.43
Ultimate: Sulphur	0.71	0.71	0.72	1.09	1.10	1.01
Ultimate: Hydrogen	....	....	5.01	....	....	4.84
Ultimate: Carbon	....	....	71.58	....	....	68.69
Ultimate: Nitrogen	....	....	1.65	....	....	1.54
Ultimate: Oxygen	....	....	8.50	....	....	11.49
Calorific value determined:						
Calories	....	7,217	7,142	7,296	7,053	6,861
British thermal units	....	12,991	12,856	13,133	12,695	12,350
Calorific value calculated from ultimate analysis:						
Calories	....	....	7,160	....	....	6,745
British thermal units	....	....	12,888	....	....	12,141

Analyses of mine and laboratory car samples of coal—Continued.

	Arkansas No 1.			Arkansas No. 2.		
	Mine sample B.	Mine sample A.	Laboratory car sample.	Mine sample B.	Mine sample A.	Laboratory car sample.
Laboratory sample No	1045	1046	1114	1049	1053	1160
Loss of moisture on air drying			2.10			1.50
Analysis of air-dried sample.						
Proximate. Moisture			1.17			0.74
Proximate. Volatile matter			17.83			16.26
Proximate. Fixed carbon			68.12			73.66
Proximate. / Ultimate. Ash			12.88			9.34
Ultimate. Sulphur			1.27			1.90
Ultimate. Hydrogen			4.00			4.13
Ultimate. Carbon			75.68			80.03
Ultimate. Nitrogen			1.47			1.40
Ultimate. Oxygen			4.70			3.20
Calorific value determined:						
Calories			7,450			7,756
British thermal units			13,410			13,961
Calorific value calculated from ultimate analysis:						
Calories			7,319			7,794
British thermal units			13,174			14,029
Analysis corrected to sample as received.						
Proximate. Moisture	1.02	0.75	3.24	0.95	0.78	2.23
Proximate. Volatile matter	17.88	18.50	17.46	18.70	16.60	16.02
Proximate. Fixed carbon	73.61	73.77	66.69	73.38	73.53	72.55
Proximate. / Ultimate. Ash	7.49	6.98	12.61	6.97	9.09	9.20
Ultimate. Sulphur	1.10	1.15	1.24	2.12	2.50	1.87
Ultimate. Hydrogen			4.15			4.24
Ultimate. Carbon			74.09			78.83
Ultimate. Nitrogen			1.44			1.38
Ultimate. Oxygen			6.47			4.48
Calorific value determined:						
Calories	8,019		7,294	7,993		7,639
British thermal units	14,434		13,129	14,387		13,750
Calorific value calculated from ultimate analysis:						
Calories			7,165			7,677
British thermal units			12,897			13,819

Analyses of mine and laboratory car samples of coal—Continued.

		Arkansas No. 3.			Arkansas No. 5.	
	Mine sample A.	Mine sample B.	Laboratory car sample.	Mine sample A.	Mine sample B.	Laboratory car sample.
Laboratory sample No	1115	1118	1296	1130	1131	1331
Loss of moisture on air drying	0.80	0.80	1.40	0.70	1.30	1.10
Analysis of air-dried sample.						
Proximate: Moisture	0.81	0.84	0.80	0.68	0.51	1.28
Proximate: Volatile matter	17.54	16.81	19.75	14.87	15.19	12.82
Proximate: Fixed carbon	73.68	69.59	67.65	77.45	76.94	73.69
Proximate: Ash	7.97	12.76	11.80	7.00	7.36	12.21
Ultimate: Sulphur	1.43	1.47	1.30	1.53	1.97	2.01
Ultimate: Hydrogen	....	....	4.07	....	....	3.74
Ultimate: Carbon	....	....	76.37	....	....	77.29
Ultimate: Nitrogen	....	....	1.55	....	....	1.39
Ultimate: Oxygen	....	....	4.91	....	....	3.36
Calorific value determined:						
Calories	7,931	....	7,586	8,017	....	7,448
British thermal units	14,275	....	13,655	14,431	....	13,406
Calorific value calculated from ultimate analysis:						
Calories	....	....	7,393	....	....	7,434
British thermal units	....	....	13,307	....	....	13,381
Analysis corrected to sample as received.						
Proximate: Moisture	1.60	1.63	2.19	1.38	1.80	2.36
Proximate: Volatile matter	17.40	16.68	19.47	14.76	15.00	12.68
Proximate: Fixed carbon	73.09	69.03	66.71	76.91	75.94	72.88
Proximate: Ash	7.91	12.66	11.63	6.95	7.26	12.08
Ultimate: Sulphur	1.42	1.46	1.28	1.52	1.94	1.99
Ultimate: Hydrogen	....	....	4.17	....	....	3.82
Ultimate: Carbon	....	....	75.31	....	....	76.44
Ultimate: Nitrogen	....	....	1.53	....	....	1.37
Ultimate: Oxygen	....	....	6.08	....	....	4.30
Calorific value determined:						
Calories	7,868	....	7,480	7,961	....	7,366
British thermal units	14,162	....	13,464	14,330	....	13,259
Calorific value calculated from ultimate analysis:						
Calories	....	....	7,289	....	....	7,353
British thermal units	....	....	13,120	....	....	13,235

Analyses of mine and laboratory car samples of coal—Continued.

		Arkansas No. 6.	Colorado No. 1.		
		Laboratory car sample.	Mine sample B.	Mine sample A.	Laboratory car sample.
Laboratory sample No		1542	1383	1397	1523
Loss of moisture on air drying		3.00	3.90	4.00	6.00
Analysis of air-dried sample.					
Proximate	Moisture	0.82	16.77	18.58	13.49
	Volatile matter	14.32	35.18	35.42	37.11
	Fixed carbon	70.62	44.29	42.38	43.03
	Ash	14.24	3.76	3.62	6.37
Ultimate	Sulphur	1.30	0.54	0.48	0.58
	Hydrogen				5.75
	Carbon				61.13
	Nitrogen				1.22
	Oxygen				24.95
Calorific value determined:					
	Calories		5,918		5,995
	British thermal units		10,652		10,791
Calorific value calculated from ultimate analysis:					
	Calories				5,859
	British thermal units				10,546
Analysis corrected to sample as received.					
Proximate	Moisture	3.80	20.02	21.84	18.68
	Volatile matter	13.89	33.81	34.00	34.88
	Fixed carbon	68.50	42.56	40.68	40.45
	Ash	13.81	3.61	3.48	5.99
Ultimate	Sulphur	1.26	0.52	0.46	0.55
	Hydrogen				6.07
	Carbon				57.46
	Nitrogen				1.15
	Oxygen				28.78
Calorific value determined:					
	Calories		5,687		5,635
	British thermal units		10,237		10,143
Calorific value calculated from ultimate analysis:					
	Calories				5,507
	British thermal units				9,913

Analyses of mine and laboratory car samples of coal—Continued.

		Illinois No. 1.			Illinois No. 2.	Illinois No. 3.		
		Mine sample A.	Mine sample B.	Laboratory car sample.	Laboratory car sample.	Mine sample A.	Mine sample B.	Laboratory car sample.
Laboratory sample No.		1095	1096	1261	1152	1170	1171	1318
Loss of moisture on air-drying.		4.40	3.20	3.70	7.10	1.50	1.80	2.70
Analysis of air-dried sample.								
Proximate	Moisture	7.08	7.09	6.28	5.31	6.00	5.63	5.96
Proximate	Volatile matter	41.12	41.66	38.92	34.29	32.16	34.93	30.29
Proximate	Fixed carbon	41.00	40.85	41.08	36.24	54.49	51.78	52.16
Proximate / Ultimate	Ash	10.80	10.40	13.72	24.16	7.26	7.67	11.59
Proximate / Ultimate	Sulphur	4.41	4.17	4.25	4.30	1.00	2.08	1.77
Ultimate	Hydrogen	....	....	5.09	4.57	....	....	4.92
Ultimate	Carbon	....	....	62.01	54.06	....	....	67.30
Ultimate	Nitrogen	....	....	1.07	0.78	....	....	1.43
Ultimate	Oxygen	....	....	13.86	12.13	....	....	12.99
Calorific value determined:								
	Calories	6,521	....	6,360	5,471	6,986	....	6,724
	British thermal units	11,738	....	11,448	9,848	12,565	....	12,103
Calorific value calculated from ultimate analysis:								
	Calories	....	....	6,263	5,516	....	....	6,615
	British thermal units	....	....	11,273	9,929	....	....	11,907
Analysis corrected to sample as received.								
Proximate	Moisture	11.17	10.06	9.75	12.03	7.50	7.34	8.50
Proximate	Volatile matter	39.31	40.33	37.48	31.86	31.68	34.29	29.47
Proximate	Fixed carbon	39.20	39.54	39.57	33.67	53.67	50.84	50.75
Proximate / Ultimate	Ash	10.32	10.07	13.20	22.44	7.15	7.53	11.28
Proximate / Ultimate	Sulphur	4.22	4.04	4.10	4.00	0.99	2.04	1.72
Ultimate	Hydrogen	....	....	5.31	5.04	....	....	5.09
Ultimate	Carbon	....	....	59.72	50.22	....	....	65.48
Ultimate	Nitrogen	....	....	1.03	0.72	....	....	1.39
Ultimate	Oxygen	....	....	16.64	17.58	....	....	15.04
Colorific value determined:								
	Calories	6,235	....	6,125	5,083	6,881	....	6,542
	British thermal units	11,223	....	11,025	9,149	12,386	....	11,776
Calorific value calculated from ultimate analysis:								
	Calories	....	....	6,031	5,124	....	....	6,436
	British thermal units	....	....	10,856	9,223	....	....	11,585

Analyses of mine and laboratory car samples of coal—Continued.

	Illinois No. 4.			Illinois No. 5.	Illinois No. 6.		
	Mine sample A.	Mine sample B.	Laboratory car sample.	Laboratory car sample.	Mine sample A.	Mine sample B.	Laboratory car sample.
Laboratory sample No.	1341	1342	1417	1556	1449	1450	1557
Loss of moisture on air-drying	3.20	3.00	1.70	12.50	5.60	4.00	9.80
Analysis of air-dried sample.							
Proximate: Moisture	12.28	11.77	11.40	5.16	9.84	10.35	5.13
Proximate: Volatile matter	32.02	33.18	32.45	34.98	36.86	35.35	32.68
Proximate: Fixed carbon	38.03	45.97	44.30	40.67	44.96	42.94	47.46
Proximate/Ultimate: Ash	7.67	9.08	11.85	19.19	8.34	11.36	14.73
Ultimate: Sulphur	0.86	1.57	1.34	3.76	3.82	3.95	4.45
Ultimate: Hydrogen	....	....	5.33	4.69	....	....	4.88
Ultimate: Carbon	....	....	61.79	58.02	....	....	60.51
Ultimate: Nitrogen	....	....	1.17	....	....	....	1.23
Ultimate: Oxygen	....	....	18.52	....	....	....	14.20
Calorific value determined:							
Calories	6,400	....	6,106	5,917	6,483	....	6,199
British thermal units	11,520	....	10,991	10,651	11,669	....	11,158
Calorific value calculated from ultimate analysis:							
Calories	....	....	6,062	....	....	....	6,059
British thermal units	....	....	10,912	....	....	....	10,906
Analysis corrected to sample as received.							
Proximate: Moisture	15.09	14.42	12.91	17.02	14.89	13.94	14.43
Proximate: Volatile matter	31.00	32.18	31.90	30.60	34.80	33.93	29.48
Proximate: Fixed carbon	46.49	44.59	43.55	35.59	42.44	41.22	42.81
Proximate/Ultimate: Ash	7.42	8.81	11.64	16.79	7.87	10.91	13.28
Ultimate: Sulphur	0.83	1.52	1.32	3.29	3.61	3.79	4.01
Ultimate: Hydrogen	....	....	5.43	5.50	....	....	5.49
Ultimate: Carbon	....	....	60.74	50.77	....	....	54.59
Ultimate: Nitrogen	....	....	1.15	....	....	....	1.11
Ultimate: Oxygen	....	....	19.72	....	....	....	21.52
Calorific value determined:							
Calories	6,195	....	6,002	5,177	6,120	....	5,591
British thermal units	11,151	....	10,804	9,319	11,016	....	10,064
Calorific value calculated from ultimate analysis:							
Calories	....	....	5,959	....	....	....	5,465
British thermal units	....	....	10,726	....	....	....	9,837

Analyses of mine and laboratory car samples of coal—Continued.

	Indiana No. 1.			Indiana No. 2.		
	Mine sample B.	Mine sample A.	Laboratory car sample.	Mine sample B.	Mine sample A.	Laboratory car sample.
Laboratory sample No	1410	1412	1507	1425	1426	1495
Loss of moisture on air drying	8.70	5.60	3.00	2.80	3.10	3.60
Analysis of air-dried sample.						
Proximate: Moisture	4.98	6.25	8.66	6.67	7.45	6.24
Proximate: Volatile matter	39.22	37.10	34.86	40.53	39.30	37.49
Proximate: Fixed carbon	45.76	46.46	42.67	43.19	44.43	42.76
Proximate / Ultimate: Ash	10.04	10.19	13.81	9.61	8.82	13.51
Ultimate: Sulphur	2.05	1.02	2.58	4.57	3.62	4.60
Ultimate: Hydrogen	....	....	5.20	....	....	5.11
Ultimate: Carbon	....	....	62.20	....	....	62.97
Ultimate: Nitrogen	....	....	1.22	....	....	1.25
Ultimate: Oxygen	....	....	14.99	....	....	12.56
Calorific value determined:						
Calories	6,912	....	6,336	6,744	....	6,410
British thermal units	12,442	....	11,405	12,139	....	11,538
Calorific value calculated from ultimate analysis:						
Calories	....	....	6,231	....	....	6,411
British thermal units	....	....	11,216	....	....	11,540
Analysis corrected to sample as received.						
Proximate: Moisture	13.25	11.50	11.40	9.28	10.32	9.62
Proximate: Volatile matter	35.81	35.02	33.81	39.40	38.08	36.14
Proximate: Fixed carbon	41.78	43.86	41.39	41.98	43.05	41.22
Proximate / Ultimate: Ash	9.16	9.62	13.40	9.34	8.55	13.02
Ultimate: Sulphur	1.87	0.96	2.50	4.44	3.51	4.43
Ultimate: Hydrogen	....	....	5.37	....	....	5.33
Ultimate: Carbon	....	....	60.34	....	....	60.70
Ultimate: Nitrogen	....	....	1.18	....	....	1.20
Ultimate: Oxygen	....	....	17.21	....	....	15.32
Calorific value determined:						
Calories	6,311	....	6,145	6,555	....	6,179
British thermal units	11,360	....	11,061	11,799	....	11,122
Calorific value calculated from ultimate analysis:						
Calories	....	....	6,044	....	....	6,180
British thermal units	....	....	10,879	....	....	11,124

Analyses of mine and laboratory car samples of coal—Continued.

	Indian Territory No. 1.			Indian Territory No. 2.		
	Mine sample B.	Mine sample A.	Laboratory car sample.	Mine sample B.	Mine sample A.	Laboratory car sample.
Laboratory sample No	1059	1060	1138	1071	1073	1184
Loss of moisture on air drying	5.00	3.10	3.30			2.80
Analysis of air-dried sample.						
Proximate: Moisture	4.07	3.79	3.87			1.70
Proximate: Volatile matter	36.65	37.41	35.73			37.19
Proximate: Fixed carbon	50.20	52.94	50.05			49.79
Proximate: Ash	9.08	5.86	10.35			11.32
Ultimate: Sulphur	1.71	1.40	1.99			1.56
Ultimate: Hydrogen			5.14			5.00
Ultimate: Carbon			69.85			71.49
Ultimate: Nitrogen			1.29			1.72
Ultimate: Oxygen			11.38			8.91
Calorific value determined:						
Calories	7,073		7,011			7,205
British thermal units	12,731		12,620			12,969
Calorific value calculated from ultimate analysis:						
Calories			6,971			7,152
British thermal units			12,548			12,874
Analysis corrected to sample as received.						
Proximate: Moisture	8.87	6.77	7.04	1.46	1.30	4.45
Proximate: Volatile matter	34.82	36.25	34.55	39.04	38.90	36.15
Proximate: Fixed carbon	47.68	51.30	48.40	53.10	52.15	48.40
Proximate: Ash	8.63	5.68	10.01	6.40	7.65	11.00
Ultimate: Sulphur	1.62	1.36	1.92	1.38	1.58	1.52
Ultimate: Hydrogen			5.34			5.17
Ultimate: Carbon			67.55			69.49
Ultimate: Nitrogen			1.25			1.67
Ultimate: Oxygen			13.93			11.15
Calorific value determined:						
Calories	6,720		6,779	7,800		7,004
British thermal units	12,096		12,202	14,040		12,607
Calorific value calculaled from ultimate analysis:						
Calories			6,740			6,952
British thermal units			12,132			12,514

Analyses of mine and laboratory car samples of coal—Continued.

	Indian Territory No. 3.			Indian Territory No. 4.		
	Mine sample B.	Mine sample A.	Laboratory car sample.	Mine sample A.	Mine sample B.	Laboratory car sample.
Laboratory sample No	1079	1080	1274	1150	1151	1470
Loss of moisture on air drying	....	....	1.20	1.60	1.90	1.40
Analysis of air-dried sample.						
Proximate: Moisture	....	....	3.45	3.75	4.69	4.91
Proximate: Volatile matter	....	....	37.45	38.15	39.76	37.79
Proximate: Fixed carbon	....	....	47.82	45.77	46.06	43.90
Proximate and Ultimate: Ash	....	....	11.28	12.33	9.49	13.40
Proximate and Ultimate: Sulphur	....	....	3.67	3.83	3.74	4.02
Ultimate: Hydrogen	....	....	4.85	....	....	4.84
Ultimate: Carbon	....	....	68.18	....	....	63.21
Ultimate: Nitrogen	....	....	1.50	....	....	1.38
Ultimate: Oxygen	....	....	10.52	....	....	13.15
Calorific value determined:						
Calories	....	....	6,927	....	6,706	6,327
British thermal units	....	....	12,469	....	12,071	11,389
Calorific value calculated from ultimate analysis:						
Calories	....	....	6,810	....	....	6,300
British thermal units	....	....	12,258	....	....	11,340
Analysis corrected to sample as received.						
Proximate: Moisture	2.97	2.93	4.61	5.29	6.50	6.24
Proximate: Volatile matter	40.43	39.02	37.00	37.54	39.01	37.26
Proximate: Fixed carbon	48.22	47.75	47.25	45.04	45.18	43.29
Proximate and Ultimate: Ash	8.38	10.30	11.14	12.13	9.31	13.21
Proximate and Ultimate: Sulphur	3.05	3.73	3.63	3.77	3.67	3.96
Ultimate: Hydrogen	....	....	4.92	....	....	4.93
Ultimate: Carbon	....	....	67.37	....	....	62.34
Ultimate: Nitrogen	....	....	1.48	....	....	1.36
Ultimate: Oxygen	....	....	11.46	....	....	14.20
Calorific value determined:						
Calories	....	6,995	6,844	....	6,579	6,238
British thermal units	....	12,591	12,319	....	11,842	11,228
Calorific value calculated from ultimate analysis:						
Calories	....	....	6,728	....	....	6,212
British thermal units	....	....	12,110	....	....	11,182

Analyses of mine and laboratory car samples of coal—Continued.

	Ind. Ter. No. 5.	Ind. Ter. No. 6.	Iowa No. 1.		
	Laboratory car sample.	Laboratory car sample.	Mine sample B.	Mine sample A.	Laboratory car sample.
Laboratory sample No.	1481	1596	1270	1271	1347
Loss of moisture on air drying	2.70	3.50	7.90	8.00	3.20
Analysis of air-dried sample.					
Proximate: Moisture	5.74	4.69	3.74	4.43	5.21
Proximate: Volatile matter	31.46	32.41	41.96	40.52	31.76
Proximate: Fixed carbon	37.05	42.91	42.89	41.65	46.51
Proximate / Ultimate: Ash	25.75	19.99	11.41	13.40	16.52
Proximate / Ultimate: Sulphur	4.06	3.32	5.12	5.42	5.20
Ultimate: Hydrogen	4.18				4.61
Ultimate: Carbon	52.39				61.80
Ultimate: Nitrogen	1.22				0.97
Ultimate: Oxygen	12.40				10.90
Calorific value determined:					
Calories	5,201		6,843		6,329
British thermal units	9,362		12,317		11,392
Calorific value calculated from ultimate analysis:					
Calories	5,231				6,230
British thermal units	9,416				11,214
Analysis corrected to sample as received.					
Proximate: Moisture	8.29	8.03	11.35	12.07	8.24
Proximate: Volatile matter	30.61	31.28	38.65	37.28	30.74
Proximate: Fixed carbon	36.05	41.40	39.49	38.32	45.02
Proximate / Ultimate: Ash	25.05	19.29	10.51	12.33	16.00
Proximate / Ultimate: Sulphur	3.95	3.20	4.72	4.99	5.03
Ultimate: Hydrogen	4.37				4.81
Ultimate: Carbon	50.98				59.82
Ultimate: Nitrogen	1.19				0.94
Ultimate: Oxygen	14.46				13.40
Calorific value determined:					
Calories	5,061		6,303		6,126
British thermal units	9,110		11,345		11,027
Calorific value calculated from ultimate analysis:					
Calories	5,090				6,031
British thermal units	9,162				10,856

Analyses of mine and laboratory car samples of coal—Continued.

		Iowa No. 2.			Iowa No. 3.	
	Mine sample B.	Mine sample A.	Laboratory car sample.	Mine sample B.	Mine sample A.	Laboratory car sample.
Laboratory sample No	1289	1291	1570	1312	1313	1434
Loss of moisture on air drying	9.30	9.50	10.40	9.60	11.00	9.80
Analysis of air-dried sample.						
Proximate: Moisture	7.00	6.63	4.25	5.33	5.51	4.52
Proximate: Volatile matter	40.65	40.82	37.02	41.82	42.04	40.96
Proximate: Fixed carbon	39.52	42.40	41.74	40.69	38.55	38.99
Proximate / Ultimate: Ash	12.83	10.15	16.99	12.16	13.90	15.53
Ultimate: Sulphur	5.49	5.74	5.20	6.52	7.59	6.83
Ultimate: Hydrogen	....	....	4.84	....	....	4.93
Ultimate: Carbon	....	....	60.36	....	....	60.62
Ultimate: Nitrogen	....	....	1.46	....	....	0.93
Ultimate: Oxygen	....	....	11.15	....	....	11.16
Calorific value determined:						
Calories	6,302	....	6,212	6,539	....	6,309
British thermal units	11,344	....	11,182	11,770	....	11,356
Calorific value calculated from ultimate analysis:						
Calories	....	....	6,183	....	....	6,271
British thermal units	....	....	11,129	....	....	11,288
Analysis corrected to sample as received.						
Proximate: Moisture	15.65	15.50	14.21	14.42	15.90	13.88
Proximate: Volatile matter	36.87	36.94	33.17	37.81	37.42	36.94
Proximate: Fixed carbon	35.84	38.37	37.40	36.78	34.41	35.17
Proximate / Ultimate: Ash	11.64	9.19	15.22	10.99	12.37	14.01
Ultimate: Sulphur	5.10	5.19	4.66	5.89	6.76	6.15
Ultimate: Hydrogen	....	....	5.50	....	....	5.52
Ultimate: Carbon	....	....	54.08	....	....	54.68
Ultimate: Nitrogen	....	....	1.31	....	....	0.84
Ultimate: Oxygen	....	....	19.23	....	....	18.80
Calorific value determined:						
Calories	5,716	....	5,566	5,911	....	5,691
British thermal units	10,289	....	10,019	10,640	....	10,244
Calorific value calculated from ultimate analysis:						
Calories	....	....	5,540	....	....	5,656
British thermal units	....	....	9,972	....	....	10,181

Analyses of mine and laboratory car samples of coal—Continued.

	Iowa No. 4.			Iowa No. 5.		
	Mine sample B.	Mine sample A.	Laboratory car sample.	Mine sample B.	Mine sample A.	Laboratory car sample.
Laboratory sample No	1323	1324	1437	1332	1333	1433
Loss of moisture on air drying	9.40	8.60	4.50	9.40	7.10	6.80
Analysis of air-dried sample.						
Proximate: Moisture	8.53	8.25	10.03	10.25	12.37	9.22
Proximate: Volatile matter	39.12	38.23	37.27	35.10	36.98	32.71
Proximate: Fixed carbon	44.55	41.40	41.22	46.12	42.95	44.52
Proximate / Ultimate: Ash	7.80	12.12	11.48	8.53	7.70	13.55
Ultimate: Sulphur	4.42	5.21	4.46	2.64	3.34	3.42
Ultimate: Hydrogen	....	....	5.31	....	....	5.35
Ultimate: Carbon	....	....	61.25	....	....	59.89
Ultimate: Nitrogen	....	....	0.94	....	....	1.22
Ultimate: Oxygen	....	....	16.56	....	....	16.57
Calorific value determined:						
Calories	6,703	....	6,237	6,442	....	6,105
British thermal units	12,065	....	11,227	11,596	....	10,989
Calorific value calculated from ultimate analysis:						
Calories	....	....	6,165	....	....	6,045
British thermal units	....	....	11,097	....	....	10,881
Analysis corrected to sample as received.						
Proximate: Moisture	17.13	16.14	14.08	18.69	18.59	15.39
Proximate: Volatile matter	35.44	34.94	35.59	31.80	34.36	30.49
Proximate: Fixed carbon	40.36	37.84	39.37	41.78	39.90	41.49
Proximate / Ultimate: Ash	7.07	11.08	10.96	7.73	7.15	12.63
Ultimate: Sulphur	4.00	4.76	4.26	2.39	3.10	3.19
Ultimate: Hydrogen	....	....	5.57	....	....	5.74
Ultimate: Carbon	....	....	58.49	....	....	55.81
Ultimate: Nitrogen	....	....	0.90	....	....	1.14
Ultimate: Oxygen	....	....	19.82	....	....	21.49
Calorific value determined:						
Calories	6,073	....	5,957	5,836	....	5,690
British thermal units	10,931	....	10,723	10,505	....	10,242
Calorific value calculated from ultimate analysis:						
Calories	....	....	5,888	....	....	5,634
British thermal units	....	....	10,598	....	....	10,141

Analyses of mine and laboratory car samples of coal—Continued.

		Kansas No. 1.			Kansas No. 2.		
		Mine sample A.	Mine sample B.	Laboratory car sample.	Mine sample A.	Mine sample B.	Laboratory car sample.
	Laboratory sample No	1018	1020	1097	1017	1019	1122
	Loss of moisture on air drying			1.30			2.00
	Analysis of air-dried sample.						
Proximate	Moisture			3.74			2.23
Proximate	Volatile matter			33.11			31.87
Proximate	Fixed carbon			50.01			47.63
Proximate / Ultimate	Ash			13.14			18.27
Ultimate	Sulphur			4.34			6.40
Ultimate	Hydrogen			4.91			4.56
Ultimate	Carbon			68.22			63.14
Ultimate	Nitrogen			1.09			0.94
Ultimate	Oxygen			8.30			6.69
	Calorific value determined:						
	Calories			6,891			6,600
	British thermal units			12,404			11,880
	Calorific value calculated from ultimate analysis:						
	Calories			6,940			6,528
	British thermal units			12,492			11,750
	Analysis corrected to sample as received.						
Proximate	Moisture	2.91	3.50	4.99	2.44	2.36	4.18
Proximate	Volatile matter	35.81	35.75	32.68	35.16	34.62	31.23
Proximate	Fixed carbon	51.73	52.83	49.36	51.80	51.23	46.68
Proximate / Ultimate	Ash	9.55	7.92	12.97	10.60	11.79	17.91
Ultimate	Sulphur	3.79	3.28	4.28	5.63	5.88	6.27
Ultimate	Hydrogen			4.98			4.69
Ultimate	Carbon			67.34			61.88
Ultimate	Nitrogen			1.08			0.92
Ultimate	Oxygen			9.35			8.33
	Calorific value determined:						
	Calories	7,193		6,801	7,246		6,468
	British thermal units	12,947		12,242	13,043		11,642
	Calorific value calculated from ultimate analysis:						
	Calories			6,850			6,397
	British thermal units			12,330			11,515

Analyses of mine and laboratory car samples of coal—Continued.

	Kansas No. 3.			Kansas No. 4.	Kansas No. 5.		
	Mine sample B.	Mine sample A.	Laboratory car sample.	Laboratory car sample.	Mine sample A.	Mine sample B.	Laboratory car sample.
Laboratory sample No	1036	1037	1086	1473	1411	1413	1567
Loss of moisture on air-drying				3.50	3.20	4.30	2.30
Analysis of air-dried sample.							
Moisture				3.57	1.97	1.56	1.84
Volatile matter				37.00	33.68	33.79	32.40
Fixed carbon				46.80	55.15	51.54	54.97
Ash				12.63	9.20	13.11	10.79
Sulphur				8.33	4.48	4.01	3.86
Hydrogen				5.04			4.96
Carbon				65.02			71.90
Nitrogen				1.07			1.09
Oxygen				7.91			7.40
Calorific value determined:							
Calories				6,854	7,418		7,333
British thermal units				12,337	13,352		13,199
Calorific value calculated from ultimate analysis:							
Calories				6,839			7,288
British thermal units				12,310			13,118
Analysis corrected to sample as received.							
Moisture	2.01	2.54	2.50	6.95	5.11	5.79	4.10
Volatile matter	35.99	35.31	33.80	35.70	32.60	32.34	31.65
Fixed carbon	46.85	52.28	51.25	45.16	53.39	49.32	53.71
Ash	15.15	9.87	12.45	12.19	8.90	12.55	10.54
Sulphur	5.27	4.47	5.68	8.04	4.34	3.84	3.77
Hydrogen			4.91	5.25			5.10
Carbon			69.07	62.74			70.25
Nitrogen			1.20	1.04			1.06
Oxygen			6.69	10.74			9.28
Calorific value determined:							
Calories		7,411	7,166	6,614	7,181		7,164
British thermal units		13,340	12,900	11,905	12,926		12,895
Calorific value calculated from ultimate analysis:							
Calories			7,111	6,600			7,121
British thermal units			12,800	11,880			12,818

Analyses of mine and laboratory car samples of coal—Continued.

	Kentucky No. 1.			Kentucky No. 2.		
	Mine sample A.	Mine sample B.	Laboratory car sample.	Mine sample A.	Mine sample B.	Laboratory car sample.
Laboratory sample No	1321	1322	1474	1365	1366	1461
Loss of moisture on air drying	1.00	0.90	1.20	2.90	2.60	2.70
Analysis of air-dried sample.						
Proximate: Moisture	1.93	1.93	1.92	5.76	5.34	5.36
Proximate: Volatile matter	36.37	37.42	36.56	39.19	38.61	38.99
Proximate: Fixed carbon	58.13	57.83	57.08	47.74	45.56	46.27
Proximate / Ultimate: Ash	3.57	2.82	4.44	7.31	10.49	9.38
Proximate / Ultimate: Sulphur	0.90	0.85	1.24	3.63	4.31	3.72
Ultimate: Hydrogen	....	....	5.36	....	....	5.33
Ultimate: Carbon	....	....	78.31	....	....	67.64
Ultimate: Nitrogen	....	....	1.85	....	....	1.25
Ultimate: Oxygen	....	....	8.80	....	....	12.68
Calorific value determined:						
Calories	8,037	....	7,955	7,063	....	6,966
British thermal units	14,467	....	14,319	12,713	....	12,539
Calorific value calculated from ultimate analysis:						
Calories	....	....	7,823	....	....	6,840
British thermal units	....	....	14,081	....	....	12,312
Analysis corrected to sample as received.						
Proximate: Moisture	2.91	2.81	3.10	8.49	7.80	7.91
Proximate: Volatile matter	36.01	37.08	36.12	38.05	37.60	37.94
Proximate: Fixed carbon	57.55	57.31	56.39	46.36	44.38	45.02
Proximate / Ultimate: Ash	3.53	2.80	4.39	7.10	10.22	9.13
Proximate / Ultimate: Sulphur	0.89	0.84	1.22	3.53	4.20	3.62
Ultimate: Hydrogen	....	....	5.43	....	....	5.48
Ultimate: Carbon	....	....	77.37	....	....	65.81
Ultimate: Nitrogen	....	....	1.83	....	....	1.22
Ultimate: Oxygen	....	....	9.76	....	....	14.74
Calorific value determined:						
Calories	7,957	....	7,860	6,858	....	6,778
British thermal units	14,322	....	14,148	12,344	....	12,200
Calorific value calculated from ultimate analysis:						
Calories	....	....	7,729	....	....	6,655
British thermal units	....	....	13,912	....	....	11,979

Analyses of mine and laboratory car samples of coal—Continued.

	Kentucky No. 3.			Kentucky No. 4.		
	Mine sample A.	Mine sample B.	Laboratory car sample.	Mine sample B.	Mine sample A.	Laboratory car sample.
Laboratory sample No	1361	1367	1506	1382	1384	1539
Loss of moisture on air drying	3.30	2.20	2.20	2.60	2.00	2.80
Analysis of air-dried sample.						
Moisture	6.00	5.91	5.85	2.06	2.82	2.54
Volatile matter	37.45	38.39	36.90	39.19	40.53	36.08
Fixed carbon	48.23	46.19	46.96	51.15	49.50	46.79
Ash	8.32	9.51	10.29	7.60	7.15	14.59
Sulphur	3.07	4.12	3.60	3.42	3.28	4.67
Hydrogen			5.27			4.53
Carbon			66.75			66.50
Nitrogen			1.43			1.28
Oxygen			12.66			8.43
Calorific value determined:						
Calories		6,797	6,829	7,336		6,830
British thermal units		12,235	12,292	13,205		12,294
Calorific value calculated from ultimate analysis:						
Calories			6,746			6,677
British thermal units			12,143			12,019
Analysis corrected to sample as received.						
Moisture	9.10	7.98	7.92	4.61	4.76	5.27
Volatile matter	36.21	37.55	36.09	38.17	39.72	35.07
Fixed carbon	46.64	45.17	45.93	49.82	48.51	45.48
Ash	8.05	9.30	10.06	7.40	7.01	14.18
Sulphur	2.97	4.03	3.52	3.33	3.21	4.54
Hydrogen			5.39			4.71
Carbon			65.29			64.65
Nitrogen			1.40			1.24
Oxygen			14.34			10.68
Calorific value determined:						
Calories		6,647	6,679	7,145		6,639
British thermal units		11,965	12,022	12,861		11,950
Calorific value calculated from ultimate analysis:						
Calories			6,598			6,490
British thermal units			11,876			11,682

Analyses of mine and laboratory car samples of coal—Continued.

	Missouri No. 1.			Missouri No. 2.			Missouri No. 3.
	Mine sample A.	Mine sample B.	Laboratory car sample.	Mine sample A.	Mine sample B.	Laboratory car sample.	Laboratory car sample.
Laboratory sample No	1041	1043	1126	1226	1227	1348	1549
Loss of moisture on air-drying	....	....	5.00	6.20	5.00	2.60	10.
Analysis of air-dried sample.							
Proximate: Moisture	....	....	3.50	9.10	8.31	9.14	5.
Proximate: Volatile matter	....	....	35.35	41.07	38.47	34.53	32.
Proximate: Fixed carbon	....	....	40.77	41.53	42.00	39.02	39.
Ash	....	....	20.38	8.30	11.22	17.31	23.
Sulphur	....	....	5.53	4.04	4.03	5.30	4.
Ultimate: Hydrogen	....	....	4.64	....	....	4.96	4.
Ultimate: Carbon	....	....	60.00	....	....	56.25	54.
Ultimate: Nitrogen	....	....	0.99	....	....	0.99	0.
Ultimate: Oxygen	....	....	8.46	....	....	15.19	12.
Calorific value determined:							
Calories	....	....	6,191	6,625	....	5,806	5,5
British thermal units	....	....	11,144	11,925	....	10,451	9,9
Calorific value calculated from ultimate analysis:							
Calories	....	....	6,206	....	....	5,719	5,5
British thermal units	....	....	11,171	....	....	10,294	9,9
Analysis corrected to sample as received.							
Proximate: Moisture	4.80	4.92	8.33	14.74	12.90	11.50	15.
Proximate: Volatile matter	38.10	38.28	33.58	38.53	36.54	33.63	28.
Proximate: Fixed carbon	42.93	42.28	38.73	38.95	39.90	38.01	34.
Ash	14.17	14.52	19.36	7.78	10.66	16.86	20.
Sulphur	5.35	5.34	5.25	3.79	3.83	5.16	3.
Ultimate: Hydrogen	....	....	4.97	....	....	5.12	5.
Ultimate: Carbon	....	....	57.00	....	....	54.79	48.
Ultimate: Nitrogen	....	....	0.94	....	....	0.96	0.
Ultimate: Oxygen	....	....	12.48	....	....	17.11	20.
Calorific value determined:							
Calories	....	6,662	5,881	6,214	....	5,655	4,[illegible]
British thermal units	....	11,992	10,586	11,185	....	10,179	8,[illegible]
Calorific value calculated from ultimate analysis:							
Calories	....	....	5,896	....	....	5,570	4,[illegible]
British thermal units	....	....	10,613	....	....	10,026	8,[illegible]

Analyses of mine and laboratory car samples of coal—Continued.

	Missouri No. 4.			Montana No. 1.	New Mexico No. 1.		
	Mine sample A.	Mine sample B.	Laboratory car sample.	Laboratory car sample.	Mine samples A & B.[a]	Mine samples C & D.[a]	Laboratory car sample.
ıboratory sample No	1446	1447	1516	1298	1023 1024	1025 1026	1278
ɔss of moisture on air drying	7.40	6.00	7.70	2.20			1.60
Analysis of air-dried samples.							
Moisture	6.42	4.86	5.39	9.05			10.86
Volatile matter	40.73	43.74	44.91	36.70			35.14
Fixed carbon	45.39	44.86	44.47	43.03			46.90
Ash	7.46	6.54	5.23	11.22			7.10
Sulphur	5.46	5.32	5.55	1.76			0.64
Hydrogen			5.77	5.25			5.73
Carbon			72.45	60.41			64.34
Nitrogen			0.75	1.36			1.05
Oxygen			10.25	20.00			21.14
ılorific value determined:							
Calories	6,962		7,516	5,987			6,353
British thermal units	12,532		13,529	10,777			11,435
ılorific value calculated from ultimate analysis:							
Calories			7,526	5,868			6,277
British thermal units			13,547	10,562			11,299
Analysis corrected to sample as received.							
Moisture	13.34	10.57	12.67	11.05	11.77	10.96	12.29
Volatile matter	37.72	41.11	41.45	35.90	41.85	42.63	34.58
Fixed carbon	42.03	42.17	41.05	42.08	43.11	42.39	46.14
Ash	6.91	6.15	4.83	10.97	3.26	4.01	6.99
Sulphur	5.06	5.00	5.12	1.73	0.54	0.52	0.63
Hydrogen			6.18	5.37			5.82
Carbon			66.87	59.08			63.31
Nitrogen			0.69	1.33			1.03
Oxygen			16.31	21.52			22.22
orific value determined:							
Calories	6,447		6,937	5,855		6,603	6,251
British thermal units	11,605		12,487	10,539		11,885	11,252
orific value calculated from ultimate analysis:							
Calories			6,946	5,739			6,177
British thermal units			12,503	10,330			11,119

[a] Average of two samples.

Analyses of mine and laboratory car samples of coal—Continued.

	New Mexico No. 2.				
	Mine sample A.	Mine sample B.	Mine sample C.	Mine sample D.	Laboratory car sample.
Laboratory sample No	1027	1028	1029	1038	1307
Loss of moisture on air drying					2.90
Analysis of air-dried sample.					
Proximate: Moisture					8.13
Proximate: Volatile matter					34.82
Proximate: Fixed carbon					37.83
Proximate and Ultimate: Ash					19.22
Ultimate: Sulphur					1.30
Ultimate: Hydrogen					5.05
Ultimate: Carbon					56.71
Ultimate: Nitrogen					0.98
Ultimate: Oxygen					16.74
Calorific value determined:					
Calories					5,668
British thermal units					10,202
Calorific value calculated from ultimate analysis:					
Calories					5,631
British thermal units					10,136
Analysis corrected to sample as received.					
Proximate: Moisture	9.13	9.68	9.40	10.80	10.79
Proximate: Volatile matter	40.77	41.42	40.05	40.35	33.82
Proximate: Fixed carbon	40.23	40.82	37.87	42.77	36.73
Proximate and Ultimate: Ash	9.87	8.08	12.68	6.08	18.66
Ultimate: Sulphur	1.27	1.55	0.84	1.06	1.26
Ultimate: Hydrogen					5.22
Ultimate: Carbon					55.07
Ultimate: Nitrogen					0.95
Ultimate: Oxygen					18.84
Calorific value determined:					
Calories		6,457			5,504
British thermal units		11,623			9,907
Calorific value calculated from ultimate analysis:					
Calories					5,468
British thermal units					9,842

Analyses of mine and laboratory car samples of coal—Continued.

	North Dakota No. 1.	North Dakota No. 2.	Pennsylvania No. 1.	Pennsylvania No. 2.	Pennsylvania No. 3.
	Laboratory car sample.	Laboratory car sample.	Steam sample.	Steam sample.	Laboratory car sample.
aboratory sample No	1279	1416			1245
oss of moisture on air-drying	23.60	24.10			3.40
Analysis of air-dried sample.					
Moisture	15.42	16.70			2.08
Volatile matter	38.73	37.10			7.27
Fixed carbon	33.61	39.49			74.32
Ash	12.24	6.71			16.33
Sulphur	2.02	0.63			0.77
Hydrogen	5.22	5.61			2.81
Carbon	52.66	55.16			75.21
Nitrogen	0.71	0.91			0.80
Oxygen	27.15	30.98			4.08
alorific value determined:					
Calories	5,034	5,273			6,929
British thermal units	9.061	9,491			12,472
alorific value calculated from ultimate analysis:					
Calories	4,931	5,071			6,886
British thermal units	8,876	9,128			12,395
Analysis corrected to sample as received.					
Moisture	35.38	36.78	1.10	0.59	5.41
Volatile matter	29.59	28.16	15.80	16.61	7.02
Fixed carbon	25.68	29.97	75.69	76.76	71.79
Ash	9.35	5.09	7.41	6.04	15.78
Sulphur	1.55	0.48	1.49	0.91	0.74
Hydrogen	6.61	6.93			3.10
Carbon	40.23	41.87			72.65
Nitrogen	0.54	0.69			0.77
Oxygen	41.72	44.94			6.96
alorific value determined:					
Calories	3,846	4,002			6,693
British thermal units	6,923	7,204			12,047
alorific value calculated from ultimate analysis:					
Calories	3,769	3,849			6,652
British thermal units	6,784	6,928			11,974

Analyses of mine and laboratory car samples of coal—Continued.

	Texas No. 1.			Texas No. 2.		
	Mine sample B.	Mine sample A.	Laboratory car sample.	Mine sample A.	Mine sample B.	Gas-producer sample.
Laboratory sample No	1195	1196	1456	1241	1243	1597
Loss of moisture on air drying	14.40	16.30	24.60	5.80	5.90	25.80
Analysis of air-dried sample.						
Proximate: Moisture	21.25	20.55	13.40	24.48	27.04	10.66
Proximate: Volatile matter	43.25	47.20	42.75	38.17	43.76	39.42
Proximate: Fixed carbon	22.85	19.41	29.00	28.94	20.17	40.11
Proximate: Ash	12.65	12.84	14.85	8.41	9.03	9.81
Ultimate: Sulphur	0.65	0.67	1.04	0.53	0.61	0.71
Ultimate: Hydrogen			5.57			5.28
Ultimate: Carbon			52.06			57.31
Ultimate: Nitrogen			0.95			1.06
Ultimate: Oxygen			25.53			25.83
Calorific value determined:						
Calories		4,741	5,199	4,716		5,502
British thermal units		8,534	9,358	8,489		9,904
Calorific value calculated from ultimate analysis:						
Calories			5,046			5,352
British thermal units			9,083			9,634
Analysis corrected to sample as received.						
Proximate: Moisture	32.58	33.50	34.70	28.86	31.34	33.71
Proximate: Volatile matter	37.02	39.50	32.23	35.96	41.18	29.25
Proximate: Fixed carbon	19.56	16.25	21.87	27.26	18.98	29.76
Proximate: Ash	10.84	10.75	11.20	7.92	8.50	7.28
Ultimate: Sulphur	0.56	0.56	0.79	0.50	0.57	0.53
Ultimate: Hydrogen			6.93			6.79
Ultimate: Carbon			39.25			42.52
Ultimate: Nitrogen			0.72			0.79
Ultimate: Oxygen			41.11			42.09
Calorific value determined:						
Calories		3,968	3,920	4,442		4,082
British thermal units		7,142	7,056	7,996		7,348
Calorific value calculated from ultimate analysis:						
Calories			3,805			3,975
British thermal units			6,849			7,155

Analyses of mine and laboratory car samples of coal—Continued.

	West Virginia No. 1.			West Virginia No. 2.		
	Mine sample B.	Mine sample A.	Laboratory car sample.	Mine sample B.	Mine sample A.	Laboratory car sample.
Laboratory sample No	1088	1089	1213	1103	1104	1308
Loss of moisture on air drying	0.40	0.40	0.40	0.90	0.80	0.50
Analysis of air-dried sample.						
Proximate: Moisture	1.00	0.95	1.35	1.09	1.08	1.46
Proximate: Volatile matter	36.80	37.50	36.92	40.91	40.62	40.14
Proximate: Fixed carbon	55.50	55.10	55.36	48.84	50.13	50.50
Ash	6.70	6.45	6.37	9.16	8.17	7.90
Sulphur	1.60	1.32	0.90	4.24	3.78	3.50
Ultimate: Hydrogen			5.26			5.09
Ultimate: Carbon			78.31			74.44
Ultimate: Nitrogen			1.55			1.37
Ultimate: Oxygen			7.61			7.70
Calorific value determined:						
Calories	7,845		7,869	7,549		7,700
British thermal units	14,121		14,164	13,588		13,860
Calorific value calculated from ultimate analysis:						
Calories			7,832			7,517
British thermal units			14,098			13,531
Analysis corrected to sample as received.						
Proximate: Moisture	1.40	1.35	1.75	1.98	1.87	1.95
Proximate: Volatile matter	36.65	37.35	36.77	40.54	40.30	39.94
Proximate: Fixed carbon	55.28	54.88	55.14	48.40	49.73	50.25
Ash	6.67	6.42	6.34	9.08	8.10	7.86
Sulphur	1.59	1.31	0.90	4.20	3.75	3.48
Ultimate: Hydrogen			5.28			5.13
Ultimate: Carbon			78.00			74.07
Ultimate: Nitrogen			1.54			1.36
Ultimate: Oxygen			7.94			8.10
Calorific value determined:						
Calories	7,813		7,837	7,481		7,661
British thermal units	14,063		14,107	13,466		13,790
Calorific value calculated from ultimate analysis:						
Calories			7,800			7,480
British thermal units			14,040			13,464

Analyses of mine and laboratory car samples of coal—Continued.

		West Virginia No. 3.			West Virginia No. 4.		
		Mine sample B.	Mine sample A.	Laboratory car sample.	Mine sample B.	Mine sample A.	Laboratory car sample.
Laboratory sample No.		1108	1109	1252	1116	1117	1262
Loss of moisture on air drying		1.50	0.80	1.30	1.10	1.20	0.50
Analysis of air-dried sample.							
Proximate	Moisture	1.42	1.42	1.00	1.17	1.07	0.98
	Volatile matter	29.08	29.68	30.25	29.03	28.88	28.72
	Fixed carbon	61.19	60.51	58.38	61.97	61.37	61.87
	Ash	8.31	8.39	10.37	7.83	8.68	8.43
Ultimate	Sulphur	0.77	0.81	1.07	0.86	1.28	0.90
	Hydrogen	....	....	4.91	....	....	4.85
	Carbon	....	....	76.12	....	....	78.21
	Nitrogen	....	....	1.44	....	....	1.50
	Oxygen	....	....	6.09	....	....	6.11
Calorific value determined:							
	Calories	7,863	....	7,631	7,863	....	7,855
	British thermal units	14,153	....	13,736	14,153	....	14,13[illegible]
Calorific value calculated from ultimate analysis:							
	Calories	....	....	7,605	....	....	7,75[illegible]
	British thermal units	....	....	13,689	....	....	13,95[illegible]
Analysis corrected to sample as received.							
Proximate	Moisture	2.90	2.21	2.29	2.26	2.26	1.4[illegible]
	Volatile matter	28.64	29.44	29.86	28.71	28.53	28.5[illegible]
	Fixed carbon	60.27	60.03	57.62	61.29	60.63	61.5[illegible]
	Ash	8.19	8.32	10.23	7.74	8.58	8.3[illegible]
Ultimate	Sulphur	0.75	0.80	1.06	0.85	1.26	0.9[illegible]
	Hydrogen	....	....	4.99	....	....	4.[illegible]
	Carbon	....	....	75.13	....	....	77.[illegible]
	Nitrogen	....	....	1.42	....	....	1.[illegible]
	Oxygen	....	....	7.17	....	....	6.[illegible]
Caloric value determined:							
	Calories	7,745	....	7,532	7,777	....	7,8[illegible]
	British thermal units	13,941	....	13,558	13,999	....	14,0[illegible]
Calorific value calculated from ultimate analysis:							
	Calories	....	....	7,506	....	....	7,7[illegible]
	British thermal units	....	....	13,511	....	....	13,8[illegible]

Analyses of mine and laboratory car samples of coal—Continued.

	West Virginia No. 5.			West Virginia No. 6.		
	Mine sample A.	Mine sample B.	Laboratory car sample.	Mine sample B.	Mine sample A.	Laboratory car sample.
Laboratory sample No	1144	1147	1297	1175	1176	1390
Loss of moisture on air drying	1.80	2.30	0.80	1.50	1.60	0.90
Analysis of air-dried sample.						
Proximate: Moisture	1.04	0.80	0.65	0.80	0.51	0.64
Proximate: Volatile matter	30.16	29.45	29.20	23.00	23.04	21.74
Proximate: Fixed carbon	58.16	59.24	59.97	70.23	72.85	72.53
Ash	10.64	10.51	10.18	5.97	3.60	5.09
Sulphur	1.02	1.15	0.99	0.74	0.76	0.66
Ultimate: Hydrogen			4.78			4.70
Ultimate: Carbon			76.36			83.62
Ultimate: Nitrogen			1.48			1.70
Ultimate: Oxygen			6.21			4.23
Calorific value determined:						
Calories	7,623		7,682		8,413	8,301
British thermal units	13,721		13,828		15,143	14,942
Calorific value calculated from ultimate analysis:						
Calories			7,572			8,208
British thermal units			13,630			14,774
Analysis corrected to sample as received.						
Proximate: Moisture	2.82	3.08	1.45	2.29	2.10	1.53
Proximate: Volatile matter	29.62	28.77	28.97	22.65	22.67	21.54
Proximate: Fixed carbon	57.11	57.88	59.48	69.18	71.68	71.88
Ash	10.45	10.27	10.10	5.88	3.55	5.05
Sulphur	1.00	1.13	0.98	0.73	0.75	0.65
Ultimate: Hydrogen			4.83			4.76
Ultimate: Carbon			75.75			82.87
Ultimate: Nitrogen			1.47			1.68
Ultimate: Oxygen			6.87			4.99
Calorific value determined:						
Calories	7,486		7,621		8,278	8,226
British thermal units	13,475		13,718		14,900	14,807
Calorific value calculated from ultimate analysis:						
Calories			7,511			8,134
British thermal units			13,520			14,641

Analyses of mine and laboratory car samples of coal—Continued.

		West Virginia No. 7.			West Virginia No. 8.		
		Mine sample B.	Mine sample A.	Laboratory car sample.	Mine sample A.	Mine sample B.	Laboratory car sample.
Laboratory sample No		1197	1198	1595	1257	1258	1515
Loss of moisture on air drying		1.70	1.50	3.20	0.60	0.60	2.60
Analysis of air-dried sample.							
Proximate	Moisture	0.80	0.63	0.76	1.31	1.25	1.60
Proximate	Volatile matter	21.65	22.07	20.54	33.54	33.20	32.12
Proximate	Fixed carbon	73.33	73.70	73.61	60.25	58.75	58.92
Proximate	Ash	4.22	3.60	5.09	4.90	6.80	7.36
Ultimate	Sulphur	1.10	0.91	1.20	0.64	0.89	0.92
Ultimate	Hydrogen	....	....	4.38	....	....	5.16
Ultimate	Carbon	....	....	82.41	....	....	78.75
Ultimate	Nitrogen	....	....	1.05	....	....	1.38
Ultimate	Oxygen	....	....	5.87	....	....	6.43
Calorific value determined:							
	Calories	....	8,412	8,254	8,077	....	7,863
	British thermal units	....	15,142	14,851	14,539	....	14,153
Calorific value calculated from ultimate analysis:							
	Calories	....	....	7,942	....	....	7,884
	British thermal units	....	....	14,296	....	....	14,091
Analysis corrected to sample as received.							
Proximate	Moisture	2.48	2.12	3.94	1.90	1.84	4.16
Proximate	Volatile matter	21.28	21.74	19.88	33.34	33.00	31.28
Proximate	Fixed carbon	72.09	72.59	71.25	59.89	58.40	57.39
Proximate	Ash	4.15	3.55	4.93	4.87	6.76	7.17
Ultimate	Sulphur	1.08	0.90	1.16	0.64	0.89	0.90
Ultimate	Hydrogen	....	....	4.60	....	....	5.3[illegible]
Ultimate	Carbon	....	....	79.78	....	....	76.70
Ultimate	Nitrogen	....	....	1.01	....	....	1.34
Ultimate	Oxygen	....	....	8.52	....	....	8.5[illegible]
Calorific value determined:							
	Calories	....	8,286	7,990	8,029	....	7,65[illegible]
	British thermal units	....	14,915	14,382	14,452	....	13,78[illegible]
Calorific value calculated from ultimate analysis:							
	Calories	....	....	7,688	....	....	7,67[illegible]
	British thermal units	....	....	13,838	....	....	13,82[illegible]

Analyses of mine and laboratory car samples of coal—Continued.

	West Virginia No. 9.			West Virginia No. 10.		
	Mine sample B.	Mine sample A.	Laboratory car sample.	Mine sample B.	Mine sample A.	Laboratory car sample.
Laboratory sample No	1208	1209	1561	1240	1241	1471
Loss of moisture on air drying	1.00	0.60	3.10	2.40	2.30	1.10
Analysis of air-dried sample.						
Proximate: Moisture	0.99	1.18	1.01	0.55	0.34	0.65
Proximate: Volatile matter	34.76	32.72	29.53	18.55	19.96	18.80
Proximate: Fixed carbon	60.45	63.14	62.67	77.20	76.50	75.92
Ash	3.80	2.96	6.79	3.71	3.20	4.63
Sulphur	0.86	0.75	0.80	0.49	0.58	0.57
Ultimate: Hydrogen	....	....	5.04	....	....	4.58
Ultimate: Carbon	....	....	79.35	....	....	85.91
Ultimate: Nitrogen	....	....	1.63	....	....	1.07
Ultimate: Oxygen	....	....	6.39	....	....	3.24
Calorific value determined:						
Calories	8,271	....	7,984	8,495	....	8,439
British thermal units	14,888	....	14,371	15,291	....	15,190
Calorific value calculated from ultimate analysis:						
Calories	....	....	7,890	....	....	8,391
British thermal units	....	....	14,202	....	....	15,104
Analysis corrected to sample as received.						
Proximate: Moisture	1.98	1.77	4.08	2.93	2.63	1.75
Proximate: Volatile matter	34.41	32.53	28.61	18.10	19.50	18.59
Proximate: Fixed carbon	59.85	62.76	60.73	75.35	74.74	75.08
Ash	3.76	2.94	6.58	3.62	3.13	4.58
Sulphur	0.85	0.74	0.77	0.48	0.57	0.56
Ultimate: Hydrogen	....	....	5.23	....	....	4.65
Ultimate: Carbon	....	....	76.89	....	....	84.97
Ultimate: Nitrogen	....	....	1.58	....	....	1.06
Ultimate: Oxygen	....	....	8.95	....	....	4.18
Calorific value determined:						
Calories	8,188	....	7,736	8,291	....	8,346
British thermal units	14,738	....	13,925	14,924	....	15,023
Calorific value calculated from ultimate analysis:						
Calories	....	....	7,645	....	....	8,298
British thermal units	....	....	13,761	....	....	14,936

Analyses of mine and laboratory car samples of coal—Continued.

	West Virginia No. 11.			West Virginia No. 12.		
	Mine sample A.	Mine sample B.	Laboratory car sample.	Mine sample A.	Mine sample B.	Laboratory car sample.
Laboratory sample No	1234	1235	1472	1238	1242	1364
Loss of moisture on air-drying	1.50	2.60	3.30	1.60	2.90	1.10
Analysis of air-dried sample.						
Proximate: Moisture	0.72	0.46	0.80	0.32	0.60	0.62
Proximate: Volatile matter	18.56	18.74	16.90	19.68	19.45	18.05
Proximate: Fixed carbon	75.40	76.11	70.80	75.54	75.93	74.38
Proximate and Ultimate: Ash	5.32	4.69	11.50	4.46	4.02	6.95
Proximate and Ultimate: Sulphur	0.45	0.51	0.53	0.53	0.75	0.69
Ultimate: Hyrogen	....	....	4.03	....	....	4.36
Ultimate: Carbon	....	....	79.12	....	....	83.63
Ultimate: Nitrogen	....	....	1.04	....	....	1.34
Ultimate: Oxygen	....	....	3.78	....	....	3.03
Calorific value determined:						
Calories	8,343	....	7,761	8,427	8,428	8,185
British thermal units	15,017	....	13,970	15,169	15,170	14,733
Calorific value calculated from ultimate analysis:						
Calories	....	....	7,631	....	....	8,144
British thermal units	....	....	13,736	....	....	14,659
Analysis corrected to sample as received.						
Proximate: Moisture	2.21	3.05	4.07	1.92	3.48	1.72
Proximate: Volatile matter	18.28	18.26	16.34	19.36	18.89	17.85
Proximate: Fixed carbon	74.26	74.12	68.47	74.33	73.73	73.5[illegible]
Proximate and Ultimate: Ash	5.25	4.57	11.12	4.39	3.90	6.8[illegible]
Proximate and Ultimate: Sulphur	0.44	0.50	0.51	0.52	0.73	0.6[illegible]
Ultimate: Hydrogen	....	....	4.27	....	....	4.4[illegible]
Ultimate: Carbon	....	....	76.51	....	....	82.7[illegible]
Ultimate: Nitrogen	....	....	1.00	....	....	1.3[illegible]
Ultimate: Oxygen	....	....	6.59	....	....	3.9[illegible]
Calorific value determined:						
Calories	8,218	....	7,505	8,292	8,184	8,09[illegible]
British thermal units	14,792	....	13,509	14,926	14,731	14,5[illegible]
Calorific value calculated from ultimate analysis:						
Calories	....	....	7,379	....	....	8,0[illegible]
British thermal units	....	....	13,282	....	....	14,4[illegible]

Analyses of mine and laboratory car samples of coal—Continued.

	Wyoming No. 1.			Wyoming No. 2.		
	Mine sample B.	Mine sample A.	Laboratory car sample.	Mine sample B.	Mine sample A.	Gas-producer sample.
Laboratory sample No	1368	1369	1479	1376	1377	1571
Loss of moisture on air drying	5.00	4.50	6.00	4.70	3.80	6.90
Analysis of air-dried sample.						
Proximate: Moisture	17.89	17.74	17.69	4.09	5.64	2.73
Proximate: Volatile matter	37.81	38.91	37.96	38.96	37.51	37.61
Proximate: Fixed carbon	40.75	38.21	39.56	33.97	35.05	37.40
Proximate/Ultimate: Ash	3.55	5.14	4.79	22.98	21.80	22.26
Ultimate: Sulphur	0.63	0.55	0.63	5.18	4.50	4.17
Ultimate: Hydrogen			5.06			4.54
Ultimate: Carbon			58.41			55.29
Ultimate: Nitrogen			1.09			0.80
Ultimate: Oxygen			28.99			12.94
Calorific value determined:						
Calories	5,728		5,753	5,660		5,758
British thermal units	10,340		10,355	10,188		10,364
Calorific value calculated from ultimate analysis:						
Calories			5,582			5,567
British thermal units			10,048			10,021
Analysis corrected to sample as received.						
Proximate: Moisture	22.00	21.44	22.63	8.60	9.23	9.44
Proximate: Volatile matter	35.92	37.16	35.68	37.15	36.08	35.02
Proximate: Fixed carbon	38.71	36.49	37.19	32.37	33.72	34.82
Proximate/Ultimate: Ash	3.37	4.91	4.50	21.90	20.97	20.72
Ultimate: Sulphur	0.60	0.53	0.59	4.94	4.33	3.91
Ultimate: Hydrogen			6.39			5.00
Ultimate: Carbon			54.91			51.46
Ultimate: Nitrogen			1.02			0.74
Ultimate: Oxygen			32.59			18.17
Calorific value determined:						
Calories	5,442		5,408	5,394		5,361
British thermal units	9,796		9,734	9,709		9,650
Calorific value calculated from ultimate analysis:						
Calories			5,247			5,183
British thermal units			9,445			9,329

WASHING TESTS.

By John D. Wick.

INTRODUCTION.

The washery plant was constructed after designs furnished by Roberts & Shaefer Company, of Chicago. It was under the immediate supervision of the writer, who was assisted by Mr. Edward Moore. The chemical analyses given in the report were made at the laboratory of the testing plant under the direction of Prof. N. W. Lord. The steam tests mentioned were made in the boiler room under the direction of Prof. L. C. Breckenridge.

Owing to the small appropriation and the great cost of all material and labor on the Exposition grounds, the washery plant was made as small as possible, consisting of four 35-ton storage bins and two bins of half the size for holding material to be washed. On account of the small size of the bins holding material to be washed, it was impossible to wash an entire carload of coal in one operation. Washing tests, therefore, had to be made in lots of 10 tons or less, and for that reason the best results were not always obtained and not many such tests were made. The lack of adequate storage facilities and the constant demand upon the conveying apparatus for supplying fuel to the boiler room, the gas-producer plant, the coke ovens, and the briquetting machines made it frequently impossible to weigh carefully the washed product and the refuse material. Although complete washing tests were made in only a few instances, considerable coal was washed for coking, but in small amounts, only sufficient for charging a single oven.

As noted in the general description of the plant (pages 10–13), the washing apparatus consisted of a New Century jig and a modified Stewart jig. The former is desiged for washing very fine material, whereas the latter will wash coal composed of pieces crushed to a diameter of 1½ inches. The tests made were not sufficiently complete to determine the efficiency of these jigs, but considerable difficulty was experienced with the New Century jig, the material being so fine that it packed in the bottom of the jig and thus prevented the discharge of the refuse material. The modified Stewart jig gave very good satisfaction, and seems very well adapted to most kinds of coal.

SPECIAL TESTS.

Complete washing tests were made upon the samples named below, and with the results stated.

ILLINOIS NO. 2.

This sample consisted of a carload of slack from the O'Fallon mine of the Western Anthracite Coal and Coke Company, near O'Fallon, Ill. The coal in this district produces considerable slack, which finds a fairly ready market in St. Louis, but the price received is hardly sufficient to pay for transportation. Washing has been introduced at a number of plants to improve the quality of the slack, with very promising results, and this test was made with the object of showing what improvement could be effected in this particular part of the district. The slack washed consisted of 27,280 pounds, which was carefully sampled before and after washing.

This coal was washed in the modified Stewart jig. The weight of the washed coal was not ascertained, but the refuse weighed 3,520 pounds.

The first column of the appended table shows the composition of the raw coal as far as its content of moisture, ash, and sulphur is concerned. The second column gives the same data for the washed coal and the third column for the refuse.

Analyses of Illinois No. 2 coal and refuse, showing effect of washing.

	Raw coal.	Washed coal.	Refuse.
Moisture	12.03	19.07	15.99
Ash	22.44	9.42	53.08
Sulphur	4.00	3.35	9.06
Weight, in pounds	27,280	....	3,520

A comparison of these figures shows that the percentage of ash was reduced from 22.44 to about 9.42 by washing, but the greater amount of moisture in the washed coal sample makes direct comparison impossible. If the analysis of the washed coal had been determined on the same basis as that of the raw coal, the percentage of ash in the latter would be about 10 per cent. This shows a reduction of fully 12 per cent in ash as a result of washing a small lot through the Stewart jig, but washing on a commercial scale might improve this result considerably.

The sulphur shows a slight reduction, about one-half of 1 per cent. It would seem from these figures either that the major portion of the sulphur is so intimately combined with the coal as to be inseparable from it, or that the sulphur is present in thin flakes which pass over with the coal.

The next important item in successful washing is the determination of the amount of coal retained in the refuse or, in other words, wasted. From the composition of the refuse and its weight the amount of coal in the refuse is about 1,000 pounds, or about 3½ per cent of the original charge, or about 5½ per cent of the coal in the original charge.

The effect of washing in improving the quality of this coal is shown by steam tests Nos. 18 and 19. Test No. 18 was made on lump coal from this mine, and test No. 19 was made on the washed slack from the same mine.

The following brief results of these tests are given:

Steam tests of lump and washed coal (Illinois No. 2).

Coal tested.	Total coal consumed.	Horse-power developed by boiler.	Dry coal burned per square foot of grate surface, per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horse-power hour.	Dry coal per electrical horse-power hour.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Lump coal	11,124	211.4	24.90	7.21	3.92	4.85
Washed slack	10,096	210.2	22.36	8.00	3.54	4.38

A small amount of this coal was also washed for coking purposes, and the improvement may be noted by comparing the results obtained from this charge with those obtained from a charge of Illinois No. 1, which consists of lump coal from the same mine. This test was made on a charge of 9,000 pounds of unwashed coal, which was burned for 43 hours. It produced some small pieces of coke mixed with charred coal and ash. This coal contained 15.95 per cent of ash, and probably for this reason failed to coke.

The second test was made on Illinois No. 2 washed. The amount of coal charged was 9,000 pounds, which, after burning 64 hours, yielded 3,389 pounds of mixed hard and soft coke and 352 pounds of breeze and ash.

From this report it is obvious that the raw lump coal did not coke but the washed slack produced coke of fair quality, although the percentage of the yield is so small that it probably would not be commercially successful.

The improvement by washing is also shown by the chemical analyses of the coal before and after washing, as follows:

Analyses showing effect of washing Illinois No. 2 coal.

	Raw coal.	Washed coal for coking.
Ash	22.44	9.19
Sulphur	4.00	3.03

INDIANA NO. 1.

This was a sample of run-of-mine coal from mine of the J. Woolley Coal Company, located at Mildred, Sullivan County, Ind. No washing is now done in this district, but the coal contains considerable impurity, and the operators are very desirous of obtaining information concerning the effectiveness of washing operations.

The charge, consisting of 15,250 pounds of run-of-mine coal, was passed through rolls having an aperture of 1¼ inches, and then washed through the modified Stewart jig.

After the coal was crushed it was sampled and analyzed, giving the figures shown in the column marked "Raw coal" in the accompanying table. After washing it was again sampled and analyzed, and the results are given in the second column of the table. The refuse was also sampled and analyzed, with the results shown in the third column.

Analyses of Indiana No. 1 coal and refuse, showing effect of washing.

	Raw coal.	Washed coal.	Refuse.
Moisture	11.40	16.72	14.85
Ash	13.40	7.16	31.71
Sulphur	2.50	2.23	5.68
Weight, in pounds	15,250	12,620	3,485
Coal, pounds	11,468	9,600	1,860

The results of this test are not so satisfactory as that of Illinois No. 2, but it is probable that equally good results could be obtained by further trials.

The test of Indiana No. 1 is satisfactory as far as the reduction of the impurities is concerned, but it is not satisfactory when it is considered that about 1,860 pounds of coal (exclusive of moisture and ash) passed over with the refuse matter. This is probably too great a loss for commercial success, but, as noted above, there is every reason to believe that washing could be done that would result in a much cleaner coal and at the same time lose but little coal with the refuse material.

A steam test was made of this coal after washing, but no test was

made on the raw coal, so it is impossible to say how great the improvement was except from the chemical analyses. The steam test on the washed coal is given in test No. 68, page 81.

A washing test was also made on about 4½ tons of this coal for coking purposes. No test was made in the coke ovens of the raw coal, hence the coke produced can not be compared, but the chemical analyses show the improvement effected, as follows:

Analyses of Indiana No. 1 coal, showing effect of washing.

	Raw coal.	Washed coal for coking.
Ash	13.40	7.04
Sulphur	2.50	2.03

MISSOURI NO. 3.

This sample consisted of a carload of slack from the Mendota Coal and Mining Company, operating at Mendota, Putnam County, Mo. Like most of the coals from northern Missouri and southern Iowa, this coal contains a heavy percentage of impurities, and the operators are very desirous of improving their product. It was for this reason that the above test was undertaken, as the results of this test will doubtless apply to the entire field in Putnam County, Mo., and Appanoose County, Iowa.

The sample, consisting of 14,000 pounds of slack, was passed through rolls having an aperture of 1¼ inches and then washed through the modified Stewart jig. After the coal was crushed it was sampled and analyzed, giving the figures shown in the column marked "Raw coal" in the accompanying table. After washing it was again sampled and analyzed, with the results given in the second column of the table. The refuse was also sampled and analyzed, with the results shown in the third column.

Analyses of Missouri No. 3 coal and refuse, showing effect of washing.

	Raw coal.	Washed coal.	Refuse.
Moisture	14.37	23.90	23.3
Ash	28.39	7.59	36.7
Sulphur	4.30	2.89	3.9
Weight, in pounds	14,000	....	4,93
Calculated weight of coal, in pounds	8,013	6,045	1,96

The refuse weighed 4,931 pounds. It appears from the chemica analysis that the raw coal contained 8,013 pounds of coal exclusive c

oisture and ash, and the refuse 1,968 pounds. The washed coal, ıerefore, must have been the difference, or 6,045 pounds.

The results given above show great improvement. The slack was ꞏtremely dirty, as the analysis shows. Washing reduced the ash om 28.39 per cent in the raw coal to 7.59 per cent in the washed ɔal. The sulphur was likewise reduced from 4.30 to 2.89 per cent. n the whole the reduction in the impurities is highly satisfactory, ıt the amount of coal lost in the operation (1,968 pounds) is too great ɪr economical work. It is possible that better results might have ꞏen obtained if the tests had been continued, but enough has been ɔne to show that great improvement may be made in the quality of e slack coal in this field by washing.

The improvement in washing this slack was still further tested by eam tests made on the raw coal and also on the washed product.

Steam tests showing effect of washing Missouri No. 3 coal.

Coal tested.	Total coal consumed.	Horsepower developed by boiler.	Dry coal burned per sq. ft. of grate surface, per hour.	Equivalent evaporation from and at 212° F., per pound of dry coal.	Dry coal, per indicated horse-power hour.	Dry coal, per electrical horse-power hour.
	Pounds.		*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
ıw slack	10,828	149.5	21.85	5.82	4.86	6.00
ashed slack	11,044	189.7	21.72	7.43	3.81	4.70

A washing test was also made of about 6½ tons of this coal for cokg purposes. No trial was made of the raw coal in the oven, so it is ıpossible to make a direct comparison of the coke, but the chemical ıalyses give some idea of the improvement produced.

Analyses showing effect of washing Missouri No. 3 coal.

	Raw coal.	Washed coal for coking.
h	28.39	7.24
lphur	4.30	2.74

GENERAL TESTS.

In addition to the above-mentioned special tests, a great many ıarges of coal for the coke ovens were washed, and generally with ꞏrly satisfactory results, considering the small amount of coal in ꞏh charge.

As previously stated, the congested condition of the conveying apparatus prevented the weighing of any of these small charges after washing, but some idea of the effects of washing may be gained by comparing the chemical analyses made before and after washing and by noting the character of coke produced when tests were made on washed and unwashed material.

Alabama No. 1.—Lump coal from mine No. 8, Ivy Coal and Iron Company, Horse Creek, Ala.

Coking tests were made of both washed and unwashed coal from this mine. The first charge of unwashed coal consisted of 8,000 pounds. Although the coking process was continued for 88 hours the coke was very light and spongy and high in ash. Washing reduced the percentage of impurities but slightly, though it is believed that with more thorough washing a coke of good quality might be obtained.

Analyses showing effect of washing Alabama No. 1 coal.

	Raw coal.	Washed coal for coking.
Ash	13.88	11.
Sulphur	.76	.

Arkansas No. 6.—Slack coal from mine No. 18, Western Coal and Mining Company, Jenny Lind, Ark.

About 5 tons of this coal were washed for coking purposes. No coke was produced, but the chemical analyses show improvement.

Analyses showing effect of washing Askansas No. 6 coal.

	Raw coal.	Washed for coki
Ash	13.81	[illegible]
Sulphur	1.26	[illegible]

Illinois No. 3—Run-of-mine coal from mine No. 3, Southern Illi Coal Mining and Washing Company, Marion, Ill.

Two coking tests were made of this coal, one of raw coal and other washed for the purpose. These tests permit direct compari and the effect of washing is plainly apparent. The unwashed ch of 9,000 pounds was tested for 43 hours. The coal lay dead in oven, burning on top, but did not coke. In the second test the ch (washed) consisted of 13,000 pounds and was burned 90 hours, y ing 6,378 pounds of coke, which was very brittle and which b up in handling into fine-fingered pieces.

The chemical composition of the two grades of coal is shown below:

Analyses showing effect of washing Illinois No. 3 coal.

	Raw coal for coking.	Washed coal for coking.
sh	10.59	5.86
lphur	1.45	1.41

Illinois No. 5.—No. 5 washed slack from mine No. 1, Donk Brothers oal and Coke Company, Collinsville, Ill.

The slack at this plant is washed and divided into five grades, and e sample consisted of No. 5, or the finest grade produced. The rticles of coal were all less than one-fourth inch in diameter. The al was washed at the mine, but owing to the overcrowded condition the washery this grade of coal carried a considerable amount of purities, mainly as a clay coating on the particles of coal. As the al did not coke in the condition received, a charge consisting of about tons was rewashed in the New Century jig. The coal was extremely et when charged, chilling the oven, and no coke was produced. though the coking test was not successful, the rewashing showed a stinct gain in the quality of the coal, but considerable coal was lost the operation. Chemical analyses show the following results:

Analyses showing effect of washing Illinois No. 5 coal.

	First charge washed.	Second charge rewashed.	Third charge washed.
h	17.56	9.18	18.16
phur	3.25	2.71	3.44

Indian Territory No 2.—Run-of-mine coal from mine No. 8, Rock and Coal Company, Hartshorne, Ind. T.

Tests were made on this coal in the raw state and also after wash-. The unwashed charge (9,000 pounds) was burned for 66 hours, l yielded 5,725 pounds of coke and 580 pounds of breeze and ash. e coke was very soft, shattered, and brittle. The washed charge s burned for 65 hours, producing a coke which had a fairly good g. It showed considerable improvement in appearance over the e made from unwashed coal. The change in the impurities is wn by the following analyses.

Analyses showing effect of washing Indian Territory No. 2 coal.

	Coal.		Coke.	
	Raw.	Washed.	From raw coal.	From washed coal
Ash	9.99	6.33	14.43	11.1[illegible]
Sulphur	1.47	1.43	1.50	1.7[illegible]

Indian Territory No 3.—Run-of-mine coal from mine No. 1, D[illegible] Edwards & Sons, Edwards, Ind. T.

Coking tests were made on this coal in both the raw and the washe[d] condition, but the washing does not appear to have been successfu[l] in reducing materially either the sulphur or the ash. No coke wa[s] made from either charge. The amount of impurities is shown in th[e] following table:

Analyses showing effect of washing Indian Territory No. 3 coal.

	Raw coal for coking.	Washed coal for coking.
Ash	9.75	7.[illegible]
Sulphur	3.16	3.[illegible]

Indian Territory No 5.—Slack and pea coal from mine No. [illegible] Western Coal and Mining Company, Lehigh, Ind. T.

About 5 tons of this slack were washed for a coking test, but wit[h]out satisfactory results so far as the production of coke is concerne[d]. The improvement effected by washing is shown in the followin[g] analyses:

Analyses showing effect of washing Indian Territory No. 5 coal.

	Car sample.	Washed coal for coking.
Ash	25.05	8.[illegible]
Sulphur	3.95	2.[illegible]

Iowa No. 1.—Lump and fine coal from mine No. 2, Anchor C[oal] Company, Laddsdale, Iowa.

About 5 tons of this coal were washed for a coking test, but the c[oal] was not tried in a raw condition, and consequently the coking t[est] affords no clue to the improvement made by washing. The chang[e is] shown by the chemical analyses.

Analyses showing effect of washing Iowa No. 1 coal.

	Car sample.	Washed coal for coking.
sh	16.0	10.25
lphur	5.03	4.61

Iowa No. 2.—Run-of-mine coal from mine No. 6, Mammoth Vein oal Company, Hamilton, Iowa.

About 5½ tons of coal were washed for a coking test. The reducon of impurities effected by washing was not great, as shown by the llowing analyses:

Analyses showing effect of washing Iowa No. 2 coal.

	Car sample.	Washed coal for coking.
sh	15.22	10.28
lphur	4.66	3.93

Iowa No. 3.—Lump coal from mine No. 4, Gibson Coal Mining ompany, Altoona, Iowa.

About 4½ tons of this coal were washed for a coking test. The provement in the quality of the coal effected by washing is shown the following analyses:

Analyses showing effect of washing Iowa No. 3 coal.

	Car sample.	Washed coal for coking.
h	14.01	8.03
phur	6.15	4.55

Iowa No. 4.—Lump coal from mine No. 3, Centerville Block Coal mpany, Centerville, Iowa.

A charge consisting of about 4½ tons of this coal was washed for king purposes. The results were not so satisfactory as those tained on other samples from this State. The analyses are given ow:

Analyses showing effect of washing Iowa No. 4 coal.

	Car sample.	Washed coal for coking.
A	10.96	7.14
phur	4.26	3.59

Iowa No. 5.—Run-of-mine coal from mine No. 1, Inland Fuel Company, Chariton, Iowa.

A charge consisting of nearly 5 tons of this coal was washed for a coking test, but the coal did not coke, although the washing was fairly successful in reducing the impurities, as shown by the following analyses:

Analyses showing effect of washing Iowa No. 5 coal.

	Car sample.	Washed coa[l] for coking.
Ash	12.63	7.9
Sulphur	3.19	2.2

Kentucky No. 3.—Run-of-mine coal from Barnsley mine, St. Bernard Mining Company, Earlington, Ky.

A charge of about 5½ tons of this coal was washed for coking purposes. It produced a coke of fair quality, although little reduction was made in the impurities by washing. The analyses are as follows

Analyses showing effect of washing Kentucky No. 3 coal.

	Car sample.	Washed coa[l] for coking
Ash	10.06	7.
Sulphur	3.52	2.

Kentucky No. 4.—Run-of-mine coal from Wheatcroft Coal and Mining Company, Wheatcroft, Ky.

A charge of about 5½ tons of this coal was washed for a coking tes[t]. Washing was very much more successful in this case than in that of t[he] other coal from Kentucky. The change is shown in the following tabl[e]

Analyses showing effect of washing Kentucky No. 4 coal.

	Car sample.	Washed c[oal] for coki[ng]
Ash	14.18	6
Sulphur	4.54	2

Missouri No. 2.—Run-of-mine coal from mine No. 8, Northwest[ern] Coal and Mining Company, Bevier, Mo.

A charge of about 6½ tons of this coal was washed for a coking t[est] with the following result:

Analyses showing effect of washing Missouri No. 2 coal.

	Car sample.	Washed coal for coking.
\sh	16.86	7.76
'ulphur	5.16	3.24

West Virginia No. 2.—Run-of-mine coal from Pitcairn mine. Pit-airn Coal Company, Clarksburg, W. Va.

Two coking tests were made on this sample, one of raw coal and one of vashed coal. This affords an additional means of judging of the effect-veness of washing, for the coke shows improvement in the second washed coal) test, which can be accounted for only by better quality f coal. The following table shows the results:

Analyses showing the effect of washing West Virginia No. 2 coal.

	Coal.		Coke.	
	Raw.	Washed.	From raw coal.	From washed coal.
sh	8.22	7.05	14.95	11.40
oke	3.38	2.84	3.40	2.24

West Virginia No. 3.—Run-of-mine coal from West Virginia Coal ompany, Richard, W. Va.

This coal was tested in the coke ovens in both the raw and the ashed condition, and a comparison of results shows that washing as one in this test had little effect. The charge that was washed weighed bout 7½ tons.

Analyses showing effect of washing West Virginia No. 3 coal.

	Coal.		Coke.	
	Raw.	Washed.	From raw coal.	From washed coal.
sh	9.75	9.01	18.18	14.27
ılphur	.99	1.18	.93	1.19

West Virginia No. 4.—Run-of-mine coal from West Virginia Coal ompany, Bretz, W. Va.

Two coking tests were made of this coal, one in the raw and one in washed condition. The charge that was washed weighed about 5 ons. The results of these tests, as shown by the analyses of the coal

and the coke, are not in harmony, so it is difficult to determine the effect of washing.

The analyses are as follows:

Analyses showing effect of washing West Virginia No. 4 coal.

	Coal.		Coke.	
	Raw.	Washed.	From raw coal.	From washed coal.
Ash	8.39	7.53	11.85	13.23
Sulphur	.86	.74	.82	.69

The change in the amount of impurities is so slight that the irregularities of sampling are probably responsible for the difference in the figures.

West Virginia No. 5.—Lump and nut coal from mine of Davis Colliery Company, Coalton, W. Va.

Three coking tests were made of this coal to determine the possibility of reducing the ash to within the limit of coke for blast furnace use. The first charge consisted of about 6½ tons of raw coal; the second charge contained about 7 tons of coal crushed in rolls to 1½ inches in size and then washed; the third charge contained about 5½ tons of coal, which was pulverized in the Williams mill and washed in the New Century jig. The results of washing are shown by the following analyses:

Analyses showing effect of washing West Virginia No. 5 coal.

	Coal.			Coke.		
	Raw.	Washed.	Pulverized and washed.	From raw coal.	From washed coal.	From pulverized and washed coal
Ash	10.73	10.28	8.19	19.14	14.81	15.9
Sulphur	.90	.91	.79	.77	.83	.8

West Virginia No. 9.—Run-of-mine coal from Vulcan mine, Moun Carbon Coal Company (Limited), Powellton, W. Va.

This coal was tested in the coke ovens in both the raw and th washed condition. The charge of raw coal contained about 4½ tor and of washed coal about 6 tons. The coke from the washed co showed much improvement over that from the unwashed coal. Th change in composition is shown by the following analyses:

Analyses showing effect of washing West Virginia No. 9 coal.

	Coal.		Coke.	
	Raw.	Washed.	From raw coal.	From washed coal.
Ash	8.07	4.51	9.15	7.38
Sulphur	.83	.90	.82	.77

West Virginia No. 12.—Run-of-mine coal from mine of the Big Sandy Coal and Coke Company, Big Sandy, W. Va.

Two coking tests were made of this coal, one of raw coal and one of washed coal. The first charge consisted of about 5½ tons of coal and the second charge of about 4½ tons. No particular change was noted in the coke made from the two grades of coal, but the analyses show a reduction of ash as follows:

Analyses showing effect of washing West Virginia No. 12 coal.

	Coal.		Coke.	
	Raw.	Washed.	From raw coal.	From washed coal.
Ash	6.16	4.90	9.43	7.55
Sulphur	.97	1.11	.83	1.01

STEAM TESTS.

By L. P. Breckenridge.

INTRODUCTION.

The following is a preliminary report of the steam tests of the coals burned under the boilers of the United States Geological Survey coal-testing plant at the Louisiana Purchase Exposition, at St. Louis. This report consists of (*a*) a short description of the methods used in testing and a table giving the important dimensions of the boilers used; (*b*) a list of the various coals tested, and (*c*) some of the important results of the tests.

METHODS OF CONDUCTING TESTS.

The method of testing fuels under boilers has been a subject of discussion for many years by the members of the American Society of Mechanical Engineers, and as the result of this discussion a standard method of conducting tests and of reporting the results has received the approval of this society. The steam tests of coal at the Geological Survey testing plant have been conducted and the results reported in accordance with these methods and forms.

The number of tests made was 78. The duration of each was planned for ten hours, and was as near this time as the conditions at the close of a test would permit. An experienced and careful fireman hand-fired all of the coals tested.

DESCRIPTION OF THE BOILERS.

There were two 210-horsepower Heine safety boilers provided for these tests. They were exactly similar in construction and setting. Each was provided with its own stack, 115 feet high and 37 inches in diameter. Each boiler was fed by its own independent injector, and no other means of supplying water to the boilers was provided. The ends of the blow-off pipes were visible during all tests.

In the next table the leading proportions of one of the boilers are given.

The boilers were cleaned externally after each test. The interior condition of each boiler was practically clean during all of the tests.

Leading proportions of Heine water-tube boilers used in coal-testing plant.

Item No.	Item.	Dimensions.
1	Rated capacity of boiler .... horsepower..	210
2	Water-heating surface .... square feet..	2,031
3	Superheating surface	None.
4	Grate area .... square feet..	40.6
5	Kind of draft	Natural.
6	Height of steel stack .... feet..	115
7	Area of steel stack .... square feet..	7.67
8	Number of tubes	116
9	Outside diameter of tubes .... inches..	3.5
10	Steam pressure .... pounds..	85
11	Observations taken every 20 minutes.	
12	Approximate duration of each trial .... hours..	10

DESCRIPTION OF THE STEAM ENGINE AND GENERATOR.

The steam generated by the boilers was largely used by an Allis-Corliss engine of 250-horsepower capacity, and the power of the engine was absorbed by a 200-kilowatt direct current, 240-volt Bullock generator, to which the engine was belted.

The engine was the simple noncondensing type. The cylinder was 22 inches in diameter and the stroke was 42 inches. The engine ran about 80 revolutions per minute.

Numerous tests made to determine the steam consumption of the engine, as well as the mechanical efficiency of the engine and generator together, gave the following average results:

Average results of engine and generator tests.

Number of pounds of steam used per hour per indicated horsepower developed by the engine	23.60
Mechanical efficiency of the engine and generator combined (per cent)	81

From these figures has been calculated the electrical horsepower delivered to the switchboard for such tests of the boilers as were not accompanied by a test of the engine and generator.

COALS TESTED.

On pages 76 to 78 the coals tested are arranged alphabetically according to the States from which they were obtained. Some of these coals were washed and some were briquetted. In all tests of coals other than slack, the coal was first passed through rolls having

an opening of $1\frac{1}{2}$ inches, which crushed it to uniform size. On pages 80 to 83 is a table which gives some of the results of the tests, and in which the character of the coal used in each boiler trial is clearly indicated.

LIST OF COALS TESTED.

Alabama No. 1. First test: Lump and nut coal from mine No. 8 of the Ivy Coal and Iron Company, Horse Creek, Ala.

Second test: Large briquettes containing 7 per cent of pitch binder. See p. 148.

Alabama No. 2. Lump, nut, and pea coal from mine No. 5 of the Galloway Coal Company, Carbon Hill, Ala.

Arkansas No. 1. First test: Lump and nut coal from mine No. 3 of the Central Coal and Coke Company, Huntington, Ark.

Second test: Large briquettes containing $9\frac{1}{4}$ per cent of pitch binder. See p. 148.

Arkansas No. 2. First test: Lump coal from mine No. 12 of the Central Coal and Coke Company, Bonanza, Ark.

Second test: Large briquettes containing 11 per cent of pitch binder. See p. 149.

Arkansas No. 3. First test: Lump and slack coal from mine No. 18 of the Western Coal and Mining Company, Jenny Lind, Ark.

Second test: Large briquettes containing 8.7 per cent of pitch binder. See p. 149.

Arkansas No. 4. First test: Large briquettes made from slack coal from several Arkansas mines, furnished by the Western Coal and Mining Company, St. Louis, Mo. Briquettes contained 6 per cent of pitch binder. See p. 151.

Second test: Small briquettes made with patent binder. See p. 151.

Arkansas No. 5. Lump and slack coal from mine No. 4 of the Western Coal and Mining Company, Coal Hill, Ark.

Colorado No. 1. Run-of-mine black lignite, from Simpson mine, of the Northern Coal and Coke Company, Layfayette, Colo.

Illinois No. 1. Lump and nut coal from mine No. 1 of the Western Anthracite Coal and Coke Company, near O'Fallon, Ill.

Illinois No. 2. Washed slack coal, from same as Illinois No. 1.

Illinois No. 3. Run-of-mine coal from mine No. 3 of the Southern Illinois Coal Mining and Washing Company, near Marion, Ill.

Illinois No. 4. First test: Lump coal from mine No. 3 of the Donk Brothers Coal and Coke Company, Troy, Ill.

Second test: Same as above.

Illinois No. 6. Run-of-mine coal from shaft No. 1 of Clover Leaf Coal Company, Coffeen, Ill.

Indiana No. 1. Washed run-of-mine coal from Mildred mine of the J. Woolley Coal Company, Mildred, Ind.

Second test: Large briquettes made from washed coal, containing 7 per cent of pitch binder. See p. 154.

Indiana No. 2. Run-of-mine coal from Electric mine of the T. D. Scales Coal Company, Boonville, Ind.

Indian Territory No. 1. Lump and slack coal from mine No. 1 of the Whitehead Coal and Mining Company, Henryetta, Ind. T.

Indian Territory No. 2. Run-of-mine coal from mine No. 8 of the Rock Island Coal Company, Hartshorne, Ind. T.

Indian Territory No. 3. Run-of-mine coal from mine No. 1 of D. Edwards & Son, Edwards, Ind. T.

Indian Territory No. 4. Lump coal from mine No. 5 of the Western Coal & Mining Company, Lehigh, Ind. T.

Iowa No. 1. Lump and fine coal from mine No. 2 of the Anchor Coal Company, Laddsdale, Iowa.

Iowa No. 2. Run-of-mine coal from mine No. 6 of the Mammoth Vein Coal Company, near Hamilton, Iowa.

Iowa No. 3. Lump coal from mine No. 4 of the Gibson Coal Mining Company, Altoona, Iowa.

Iowa No. 4. First test: Lump coal from mine No. 3 of the Centerville Block Coal Company, Centerville, Iowa.

Second test: Large briquettes containing 8 per cent of pitch. See p. 158.

Iowa No. 5. Run-of-mine coal from Inland mine No. 1 of the Inland Fuel Company, Chariton, Iowa.

Kansas No. 1. Run-of-mine coal from mine No. 10 of the Western Coal and Mining Company, Fleming, Kans.

Kansas No. 2. First test: Lump and nut coal from mine No. 11 of the Western Coal and Mining Company, Yale, Kans.

Second test: Same as above except washed.

Kansas No. 3. First test: Run-of-mine coal from mine No. 9 of the Southern Coal and Mercantile Company, Scammon, Kans.

Second test: Same as above.

Kansas No. 4. Lump coal from mine of the Atchison Coal Mining Company, near Atchison, Kans.

Kansas No. 5. Lump and nut coal from mine No. 11 of the Southwestern Development Company, West Mineral, Kans.

Kentucky No. 1. Run-of-mine coal from Straight Creek mine No. 2 of the National Coal and Iron Company, Straight Creek, Ky.

Kentucky No. 2. First test: Lump, nut, pea, and slack coal from mine No. 11 of the St. Bernard Mining Company, Earlington, Ky.

Second test: Large briquettes containing 8 per cent of pitch. See p. 160.

Kentucky No. 3. Run-of-mine coal from Barnsley mine of the St. Bernard Mining Company, near Earlington, Ky.

Kentucky No. 4. Run-of-mine coal from mine or the Wheatcroft Coal and Mining Company, Wheatcroft, Ky.

Missouri No. 1. First test: Run-of-mine coal from New Home mine No. 1 of the New Home Coal Company, located at Sprague, Mo.

Second test: Large briquettes containing 11½ per cent of pitch. See p. 160.

Third test: Same as test No. 1.

Missouri No. 2. First test: Run-of-mine coal from mine No. 8 of the Northwestern Coal and Mining Company, Bevier, Mo.

Second test: Same as above.

Missouri No. 3. First test: Slack coal from mine of the Mendota Coal and Mining Company, Mendota, Mo.

Second test: Same as above except washed.

Missouri No. 4. Run-of-mine coal from mine of Morgan County Coal Company, near Barnett, Mo.

New Mexico No. 1. Lump and slack coal from Weaver mine of the American Fuel Company, 3 miles north of Gallup, N. Mex.

New Mexico No. 2. First test: Slack coal from Otero mine of the Caledonian Coal Company, 2 miles east of Gallup, N. Mex.

Second test: Small briquettes containing patent binder. See p. 162.

North Dakota No. 1. Run-of-mine brown lignite from Lehigh, N. Dak.

Pennsylvania No. 1. Coal from Eureka mine No. 31 of Berwind-White Coal Mining Company, Windber, Pa.

Pennsylvania No. 2. Coal from Eureka mine No. 31 of Berwind-White Coal Mining Company, Windber, Pa.

Pennsylvania No. 3. Small briquettes made with patent binder from anthracite culm furnished by Pennsylvania Coal Company, Scranton, Pa., p. 164.

West Virginia No. 1. Run-of-mine coal from mine of the Virginia and Pittsburg Coal Company, Kingmont, W. Va.

West Virginia No. 2. Run-of-mine coal from Pitcairn mine of the Pitcairn Coal Company, Clarksburg, W. Va.

West Virginia No. 3. Run-of-mine coal from mine of West Virginia Coal Company, Richard, W. Va.

West Virginia No. 4. Run-of-mine coal from mine of the West Virginia Coal Company, Bretz, W. Va.

West Virginia No. 5. Lump and nut coal from mine of the Davis Colliery Company, Coalton, W. Va.

West Virginia No. 6. First test. Run-of-mine coal from mine of the New River Smokeless Coal Company, Rushrun, W. Va.

Second test. Same as above.

West Virginia No. 7. Run-of-mine coal from mine of the New River Smokeless Coal Company, Sun, W. Va.

West Virginia No. 8. Run-of-mine coal from mine of the Gauley Mountain Coal Company, Ansted, W. Va.

West Virginia No. 9. Run-of-mine coal from Vulcan mine of the Mount Carbon Coal Company, Limited, Powellton, W. Va.

West Virginia No. 10. Lump and run-of-mine coal from Stuart M. Buck, Mora, W. Va.

West Virginia No. 11. Run-of-mine coal from mines Nos. 1 and 2 from W. H. Coffman, Zenith, Va.

West Virginia No. 12. First test. Run-of-mine coal from mine of the Big Sandy Coal and Coke Company, Big Sandy, W. Va.

Second test. Small briquettes made with patent binder.

Wyoming No. 1. Black lignite from mine of the Wyoming Coal and Mining Company, Monarch, Wyo.

Wyoming No. 2, Run-of-mine coal from Antelope Nos. 1 and 2 and Jumbo mines of the Cambria Fuel Company, Cambria, Wyo.

RESULTS OF THE COAL TESTS UNDER THE BOILERS.

The accompanying table shows some of the most important practical results of the tests of coals burned under the boilers. In each test an effort was made to operate the boiler at a point very near its rated capacity. In some cases the coals tested presented difficulties which made it impossible to accomplish this result. The various coals were tested in the order of the "test numbers" given in column 1, and tests of coals from widely separated localities were frequently made on successive days.

Attention is called to "rate of combustion" at which the coals were burned. To those familiar with tests of this character it will be evident that the coals were for the most part burned at a rate calculated to give approximately the most favorable results.

All of the chemical results reported in this table were furnished by the chemical laboratory in charge of Prof. N. W. Lord, which is sufficient guarantee of the accuracy.

The "horsepower developed by the boiler," recorded in column 11 refers to the standard boiler horsepower and is the evaporation of 34.

pounds of water per hour from a feed-water temperature of 212° F. and at atmospheric pressure.

In column 13 will be found recorded the number of pounds of water evaporated by one pound of dry coal at and from a temperature of 212° F. This column gives the best comparative results of the relative values of the coals tested, as far as these results relate to their commercial values.

The final report on these tests will give the values of all the items of the standard code report of the American Society of Mechanical Engineers and the complete logs of all tests, as well as a graphic chart of each trial.

Results of coal tests under boilers.

Test No.	Name of sample.	Coal, size, and condition.	Chemical composition. Fixed carbon.	Chemical composition. Volatile matter.	Chemical composition. Moisture.	Chemical composition. Ash.	Chemical composition. Sulphur (separately determined).	Duration of trial.	Total coal consumed.	Horsepower developed by boiler.	Dry coal burned per square foot of grate surface per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horsepower hour.	Dry coal per electrical horsepower hour.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Hours.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
17	Alabama No. 1	Nut, bright	52.52	31.00	2.56	13.92	0.78	10.03	8,656	205.8	20.72	8.44	3.35	4.14
21	.....do	Large briquettes	50.96	33.00	2.63	13.41	.94	8.25	6,521	196.6	18.97	8.81	3.21	3.96
16	Alabama No. 2	Mine run, bright	48.65	32.98	4.83	13.54	1.17	10.02	9,198	216.4	21.54	8.55	3.31	4.08
9	Arkansas No. 1	Lump, bright	66.36	18.61	1.99	13.04	1.21	10.07	7,071	180.5	16.90	9.05	3.12	3.86
14	.....do	Large briquettes	67.65	21.21	.94	10.20	1.73	10.03	7,700	206.4	18.74	9.37	3.02	3.73
8	Arkansas No. 2	Lump, bright	73.65	16.86	1.07	8.42	1.95	10.07	6,517	180.6	15.70	9.73	2.91	3.59
11	.....do	Large briquettes	60.30	22.49	4.88	12.33	1.32	9.98	7,370	190.3	17.31	9.31	3.00	3.71
29	Arkansas No. 3	Mine run, bright	72.74	16.04	1.97	9.25	1.29	10.02	8,158	219.7	19.68	9.50	2.98	3.68
35	.....do	Large briquettes	62.04	17.35	2.60	18.01	1.41	10.08	8,600	200.8	20.49	8.34	3.39	4.19
40	Arkansas No. 4	.....do	71.98	14.06	3.85	10.11	1.64	9.95	8,142	214.5	19.41	9.40	3.01	3.72
42	.....do	Small briquettes	66.03	18.60	3.18	12.19	1.70	7.03	5,238	166.8	17.78	7.98	3.54	4.38
41	Arkansas No. 5	Nut, bright	73.68	12.54	2.22	11.56	2.39	10.13	9,000	202.4	21.42	8.04	3.52	4.34
75	Colorado No. 1, lignite	.....do	39.00	35.85	19.78	5.37	.42	9.97	8,972	151.0	17.80	7.21	3.92	4.85
18	Illinois No. 1	Nut, dull	38.21	36.91	9.69	15.19	4.40	9.93	11,124	211.4	24.90	7.21	3.92	4.85
19	Illinois No. 2	Slack, dull, washed	41.72	37.77	10.45	10.06	3.36	9.97	10,096	210.2	22.36	8.00	3.54	4.38
38	Illinois No. 3	Nut, dull	48.75	31.19	8.51	11.55	1.50	10.13	9,537	200.6	21.23	8.04	3.52	4.34
48	Illinois No. 4	Lump, dull	41.59	33.48	13.47	11.46	1.28	10.07	9,367	172.0	19.84	7.37	3.83	4.73
50	.....do	Nut, dull	43.63	32.44	12.58	11.55	1.36	10.02	10,750	197.8	23.13	7.27	3.89	4.8
73	Illinois No. 6	.....do	39.62	32.31	13.19	14.88	3.48	9.92	10,343	194.3	22.34	7.40	3.82	4.72
71	Indiana No. 1	Large briquettes	43.23	38.79	11.74	6.24	2.03	6.60	6,579	222.6	21.70	8.73	3.24	4.00

65	Indiana No. 2	Nut, dull	40.40	38.04	9.11	12.45	4.12	10.13	9,274	193.4	20.51	8.02	3.53	4.35
10	Indian Territory No. 1	Mine run, bright	46.30	33.96	7.65	12.09	1.80	9.75	8,210	194.7	19.17	8.64	3.27	4.04
20	Indian Territory No. 2	Nut, bright	50.31	36.21	3.71	9.77	1.39	10.17	9,213	212.9	21.50	8.42	3.36	4.15
32	Indian Territory No. 3	....do	47.58	37.30	4.79	10.33	3.93	10.02	9,145	205.9	21.43	8.17	3.46	4.27
52	Indian Territory No. 4	....do	45.33	35.44	6.24	12.99	3.86	10.22	9,296	186.1	21.04	7.53	3.76	4.64
45	Iowa No. 1	Nut, dull	39.89	33.08	8.69	18.34	6.39	10.02	10,331	197.7	23.23	7.24	3.91	4.82
67	Iowa No. 2	Nut, very dirty	33.73	35.35	14.88	16.04	4.73	9.92	10,986	192.7	23.28	7.05	4.01	4.95
49	Iowa No. 3	Nut, dull	35.77	36.14	12.44	15.65	6.07	10.03	10,668	189.3	22.96	7.02	4.03	4.97
47	Iowa No. 4	Mine run, dull	37.28	34.09	13.48	15.15	5.04	10.00	9,385	167.3	20.02	7.11	3.98	4.91
66	....do	Large briquettes	37.85	36.50	13.24	12.41	3.90	10.03	9,900	184.5	21.11	7.43	3.80	4.70
55	Iowa No. 5	Nut, medium bright	38.83	31.76	16.01	13.40	3.09	9.98	11,200	204.7	23.23	7.50	3.77	4.66
6	Kansas No. 1	Lump, dull	49.46	33.78	5.90	10.86	3.82	10.10	7,222	158.2	16.60	8.11	3.49	4.31
7	....do	Mine run, dull	48.57	32.68	4.80	13.95	4.94	9.70	7,492	184.0	18.13	8.63	3.28	4.05
5	Kansas No. 2	....do	46.68	31.23	4.18	17.91	6.27	7.00	5,600	181.5	18.90	8.17	3.46	4.28
13	....do	Nut, dull, washed	51.22	34.32	5.82	8.64	3.77	9.38	8,111	209.8	20.08	8.89	3.18	3.93
3	Kansas No. 3	Mine run, dull	50.99	33.52	2.03	13.46	5.39	9.91	7,700	169.6	18.77	7.69	3.68	4.55
4	....do	....do	51.05	34.30	2.25	12.40	4.80	10.40	7,101	148.8	16.45	7.69	3.68	4.55
58	Kansas No. 4	Nut bright	43.59	36.32	5.51	14.58	8.46	10.05	7,835	165.5	18.18	7.75	3.65	4.51
72	Kansas No. 5	....do	51.36	32.42	4.31	11.91	4.40	9.90	8,651	215.2	20.62	8.88	3.18	3.93
60	Kentucky No. 1	Nut, very clean	55.59	35.61	2.89	5.91	1.19	10.03	8,355	212.3	19.95	9.06	3.12	3.86
57	Kentucky No. 2	Nut, bright	45.75	37.91	7.76	8.58	3.37	10.00	9,557	208.5	21.75	8.16	3.47	4.28
76	....do	Large briquettes	44.32	37.07	7.11	11.50	3.71	9.82	9,371	207.1	21.87	8.06	3.51	[illegible]
64	Kentucky No. 3	Nut, bright	44.84	37.32	7.92	9.92	3.91	10.07	9,645	211.5	21.75	8.27	3.42	4.22
62	Kentucky No. 4	....do	45.74	35.65	5.89	12.72	3.72	9.93	9,386	211.7	21.90	8.21	3.44	4.25
12	Missouri No. 1	Mine run, dull	40.64	34.88	7.28	17.20	4.37	10.00	9,737	207.4	22.30	7.92	3.57	[illegible]
23	....do	Large briquettes	41.85	37.60	6.38	14.17	4.56	5.10	4,500	191.2	20.37	7.99	3.54	[illegible]
15	....do	Nut, dull, washed	44.21	36.81	7.93	11.05	3.58	9.91	9,041	207.0	20.71	8.50	3.33	[illegible]
37	Missouri No. 2	Nut, dull	37.33	32.88	13.09	16.70	4.92	9.98	11,650	208.2	25.00	7.08	3.99	4.93
44	....do	....do	39.76	31.77	11.57	16.90	4.60	9.98	9,248	172.5	20.20	7.26	3.90	4.81

Results of coal tests under boilers—Continued.

Test No.	Name of sample.	Coal, size, and condition.	Chemical composition.					Duration of trial.	Total coal consumed.	Horsepower developed by boiler.	Dry coal burned per square foot of grate surface per hour.	Equivalent evaporation from and at 212° F. per pound of dry coal.	Dry coal per indicated horsepower hour.	Dry coal per electrical horsepower hour.
			Fixed carbon.	Volatile matter.	Moisture.	Ash.	Sulphur (separately determined).							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Hours.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
78	Missouri No. 3	Nut, dull	29.98	26.18	18.63	25.21	3.85	9.95	10,828	149.5	21.85	5.82	4.86	6.00
77	....do	Nut, dull, washed	39.61	31.18	20.78	8.43	2.88	9.93	11,044	189.7	21.72	7.43	3.81	4.70
70	Missouri No. 4	Nut, dull	42.11	40.10	12.24	5.55	4.98	9.98	9,515	214.1	20.64	8.83	3.20	3.96
27	New Mexico No. 1	Mine run, clean	41.57	37.85	11.90	8.68	.56	10.05	10,963	206.3	23.70	7.41	3.96	4.90
26	New Mexico No. 2	Pea, dull	36.11	37.30	9.92	16.67	1.13	10.00	11,870	198.5	26.37	6.41	4.41	5.45
30	....do	Small briquettes	39.07	37.56	6.75	16.62	1.61	8.12	7,765	185.8	22.00	7.19	3.93	4.86
33	North Dakota No. 1, lignite	Nut, brown	25.40	28.13	35.84	10.63	1.68	9.85	10,680	108.9	17.15	5.40	5.24	6.47
1	Pennsylvania No. 1	Mine run, bright	75.69	15.80	1.10	7.41	1.49	9.88	6,365	166.9	15.70	9.04	3.11	3.84
2	Pennsylvania No. 2	....do	76.76	16.61	.59	6.04	.91	10.08	6,835	191.2	16.60	9.79	2.89	3.57
36	Pennsylvania No. 3	Small briquettes	55.00	27.62	3.00	14.38	1.13	10.08	8,012	184.5	19.01	8.26	3.42	4.23
24	West Virginia No. 1	Nut, bright	56.25	34.64	1.90	7.21	.98	9.98	7,818	199.2	18.94	8.95	3.16	3.90
25	West Virginia No. 2	Mine run, bright	48.80	39.23	2.01	9.96	2.71	10.22	8,354	212.4	19.75	9.14	3.09	3.82
28	West Virginia No. 3	Nut, bright	56.11	30.31	2.54	11.04	1.38	9.97	8,225	211.6	19.82	9.08	3.11	3.84
31	West Virginia No. 4	....do	59.84	27.64	2.53	9.99	.96	10.00	7,895	215.1	18.98	9.65	2.93	3.62
34	West Virginia No. 5	....do	58.66	28.95	2.11	10.28	1.01	10.08	7,700	207.8	18.44	9.59	2.95	3.81
39	West Virginia No. 6	....do	70.03	22.38	2.14	5.45	.70	9.95	7,406	213.2	17.95	10.09	2.80	3.46
43	....do	....do	71.42	21.44	2.11	5.03	.64	10.18	7,264	208.5	17.21	10.30	2.74	3.39
51	West Virginia No. 7	....do	68.27	20.23	2.68	8.82	1.52	10.18	7,700	210.1	18.15	9.85	2.87	3.55
53	West Virginia No. 8	....do	56.68	31.19	5.26	6.87	.74	9.98	7,997	211.6	18.72	9.62	2.94	3.63
60	West Virginia No. 9	....do	59.47	31.11	3.42	6.00	.82	10.00	7,464	210.8	17.78	10.09	2.80	3.46

56	West Virginia No. 11	....do	68.36	16.31	4.85	10.48	.47	9.97	7,700	213.7	18.13	10.03	2.82	3.48
46	West Virginia No. 12	....do	75.33	18.26	1.58	4.83	.59	10.13	7,399	206.1	17.68	9.90	2.86	3.53
59	....do	Small briquettes	67.46	24.02	2.32	6.20	.84	10.25	7,515	211.8	17.66	10.20	2.77	3.42
63	Wyoming No. 1	Nut, bright	31.61	40.56	21.81	6.02	.63	10.15	11,946	186.6	22.69	7.00	4.04	4.99
61	Wyoming No. 2	Nut, very dirty	34.58	35.55	11.10	18.77	3.87	9.95	12,028	184.3	26.51	5.92	4.77	5.90

PERSONNEL.

The coal tests under steam boilers were all made under the direc supervision of Prof. D. T. Randall, of the Department of Mechanica Engineering at the University of Illinois. He was assisted by Messrs J. J. Harman, H. B. Dirks, R. H. Kuss, H. Kreisinger, C. H. McClure R. W. Rutt, C. H. Green, R. H. Post, and H. W. Weeks, the first thre being replaced by the last three on September 1. Mr. Henry Aren was fireman for all the trials, and his work was intelligent and satis factory. Mr. William Cameron fired the auxiliary boiler. The engin was under the charge of Mr. Otto Kinner, who was assisted by Mr H. M. Horstmeier, oiler. The electrical apparatus was in charge o Mr. Jos. Underwood, who was assisted by Mr. A. P. Bridgeman, i charge of the switchboard.

The work of all the corps of observers was performed with an intel ligent realization of the importance of the work and with painstakin accuracy.

PRODUCER-GAS TESTS.

By Robert H. Fernald.

INTRODUCTION.

In presenting this brief preliminary report of the producer-gas tests io attempt is made to give detailed information, as the complete eport, to be published later, will deal at length with the methods mployed in conducting the tests, details of apparatus used, and methds of working up the results from the data obtained.

EQUIPMENT.

The plant installed is a Taylor pressure gas producer, furnished by :. D. Wood & Co., of Philadelphia. The producer of 250-horsepower apacity is known as a No. 7 gas producer. It is $8\frac{1}{2}$ feet external iameter and 15 feet high and is connected through an economizer 3 eet in external diameter and 16 feet high to a scrubber, whose exteral dimensions are 8 feet in diameter by 20 feet in height. The rubber is filled with gas-house coke, which is constantly flushed with ater during the operation of the plant. From the scrubber the gas isses to the tar extractor, a piece of apparatus whose detailed conruction is carefully guarded by the manufacturers of the producer, it which resembles in outward appearance a centrifugal pump. The beed of rotation of this device is of vital importance in tar extraction. fter passing through the tar extractor the gas goes directly to the irifier, an iron box 8 feet square and 3 feet 3 inches in height. This ox is filled with oxidized iron filings and shavings that remove the lphur from the gas, which next passes to the holder, a receiver a tle over 20 feet in diameter and 13 feet high, of 4,000 cubic feet pacity. From the holder the gas is conducted through a meter of 000,000,000 cubic feet capacity to a 3-cylinder vertical Westinguse gas engine with cylinders of 19-inch diameter and 22-inch stroke, ted at 235 brake horsepower. The engine is in turn belted to a sixle 175-kilowatt Westinghouse direct-current generator. The load the generator is controlled by and the energy developed dissipated rough water rheostats especially constructed for the purpose.

The instruments and apparatus used in connection with the test were loaned by the manufacturers or dealers. These instrument are all standard, and were frequently calibrated at the Nationa Bureau of Standards in the Electricity Building, World's Fai Grounds.

During the charging of the producer the coal was carefully sampled the sample analyzed, and the calorific value of the coal determined a the chemical laboratory operated in connection with the plant. Th coal analyses in the appended table were supplied by Prof. N. W Lord, in charge of the chemical laboratory.

The calorimetric determinations from the gas and the gas analyse were made in an independent laboratory provided in the engine roon near the producer plant.

Observations and readings were taken every twenty minutes durin these tests, as were also the calorimetric determinations from the gas but in the majority of tests the gas analyses were made once ever two hours only.

PERSONNEL.

During the first few weeks the gas producer was operated under th direct supervision of Mr. C. W. Lummis, a representative of R. I Wood & Co. Mr. Lummis was followed by Mr. C. O. Nordenso also from R. D. Wood & Co., who continued in charge of the oper tions of the producer to the close of the season. The gas engine h been run by Mr. J. G. Culbertson, a representative of the Westin house Machine Company.

The observations and computations have been made by a crew college men, who have been trained in various technical institutio and who have supplemented this training with practical experienc The men employed in these two important departments are Mess R. W. Cummings, H. G. Ecker, H. A. Grine, M. H. Mount, R. Peshak, Kurt Toensfeldt, and W. C. Weidmann.

A double check system has been maintained throughout all comp tations, thus assuring a high degree of accuracy. The operati supervision of the tests has been under the direct control of Ca John A. Laird, a consulting engineer of St. Louis.

METHODS OF CONDUCTING TESTS.

The tests were begun on the basis of a total of fifty hours for ea test. The plant was operated ten hours a day and then fires w banked for the night, the records being continued the next morni This permitted one test a week only. With the small crew at co mand it seemed to be the best possible arrangement and was contin for the first two tests. It was then thought desirable to sec double the number of tests, and the schedule was arranged to cond

wo tests per week, each of thirty consecutive hours, allowing suffi-ient time between tests to make the necessary change of fuel and to nable the fuel bed in the producer to be brought to a proper vorking condition.

As it was desired to test as many coals as possible in the few weeks emaining before the close of the Exposition, the highest possible conomy was made a secondary consideration, and for a part of the ime the plant was run with a leaky hopper and other unfortunate onditions, which naturally impaired its efficiency.

In comparing the results it should be borne in mind that in these preliminary tests the object has been to demonstrate the possibility of ising these coals in a producer, and not to show how efficiently they ould be burned. Although the results in many cases have been highly atisfactory, there is no question that in a second series of tests upon he same coals, made with the idea of showing the greatest economy, he amount of coal per horsepower per hour will, in the majority of ases, be much less.

During tests Nos. 5 to 14 inclusive the hopper of the gas producer eaked, and considerable gas was wasted, thus vitiating to a small but ndetermined extent the efficiency results that might otherwise be hown for the coals tested during that period. But at the time of naking these tests it was not practicable to stop the operations of the lant for repairs; and the main purpose of the preliminary tests being o determine whether the coals were suitable for producer-gas purposes, was decided to proceed, in spite of the leak in the hopper, and to epeat later, under more favorable conditions, the tests for relative fficiency.

These points should be kept carefully in mind in examining the ppended report, and criticism of the relatively poor showing of one oal as compared with another should be reserved until after the pub-cation of the detailed report, which will give a full statement of the onditions under which each coal was tested and the influences that ended to make that particular test more or less favorable when com-ared with others.

The results show with what ease gas may be produced from bitumi-ous coal and lignites, and, taken as a whole, indicate the satisfactory conomic results that may be expected under ordinary working onditions.

Immediately after the close of the Exposition, it having been decided o continue the tests for some weeks longer, the plant was shut down order to repair the leaking hopper and to prepare for cold weather. perations were resumed on December 12 and continued until Decem-er 22, which is the close of the period covered by this report.

A glance at the logs of the tests shows very clearly the advisability f allowing a few hours for the manipulation of the plant after start-

ing before beginning the official records of the tests. This is due t the fact that each test is made on a new coal, whose working qualiti in the producer are entirely unknown. The operation of the ga engine upon gases from different coals requires careful study in ord to secure the best mixture, proper point of ignition, etc. It has ther fore been decided, should the operation of the plant be continue that seventy-two consecutive hours shall be allowed for each tes During the first eight to twelve hours the operators of the produc and engine will devote their entire attention to securing the best po sible manipulation of the plant, thus insuring sixty hours for obtaini results of high economy as well as testing the endurance of the plan

RESULTS OF THE TESTS.

The first official producer-gas test began October 3, 1904, and betwe that date and December 22 eighteen coals were tested. The resul are given briefly in the following pages.

The brief notes appended to the reports of each test give an idea the operating qualities of the coals from the standpoint of the expe in charge of the producer.

COAL, ALABAMA NO. 2; PRODUCER-GAS TEST NO. 2.

[Coal from mine No. 5 of the Galloway Coal Company, Carbon Hill, Ala.; tested October 10, 11, 12, 14, 1904.]

Duration of test .... hours..	43
Total coal consumed in producer .... pounds..	13,350
Moisture in coal .... per cent..	3.
Dry coal consumed in producer .... pounds..	12,848
Refuse from dry coal .... per cent..	9.
Total refuse from coal .... pounds..	1,315
Total combustible[a] consumed in producer .... do....	12,035

Coal consumed, pounds per hour.

Coal consumed in producer	310
Dry coal consumed in producer	299
Combustible consumed in producer	280
Equivalent coal[b] used by producer plant	341
Equivalent dry coal used by producer plant	328
Equivalent combustible used by producer plant	306

British thermal units.[c]

Per pound of coal	12,865
Per pound of dry coal	13,365
Per pound of combustible	14,820
Per cubic foot of standard gas	14[illegible]
From standard gas[d] per pound dry coal burned in producer	9,00[illegible]
From standard gas per hour per brake horsepower	11,42[illegible]

[a] "Combustible" is dry coal minus refuse.

[b] "Equivalent coal" is coal actually consumed in producer plus the coal equivalent of the st used in operating the producer.

[c] A "British thermal unit" is the heat required to raise 1 pound of water from 62° F. to 63° F.

[d] "Standard gas" is gas at 62° F. and 14.7 pounds pressure.

Gas produced, cubic feet (reduced to standard).

Total	775,500
Per hour	18,050
Per pound coal consumed in producer	58.1
Per pound dry coal consumed in producer	60.4
Per pound combustible consumed in producer	64.5
Per pound equivalent coal used by producer plant	52.9
Per pound equivalent dry coal used by producer plant	55
Per pound equivalent combustible used by producer plant	58.9

Horsepower developed.

Average electrical horsepower available for outside purposes	192.6
Average electrical horsepower developed at switch board	200.6
Average brake horsepower † available for outside purposes	226.6
Average brake horsepower † developed at engine	235.5

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower available for outside purposes	1.61	1.55	1.45
Per electrical horsepower developed at switch board	1.55	1.49	1.40
Per brake horsepower † available for outside purposes	1.37	1.32	1.23
Per brake horsepower † developed at engine	1.32	1.27	1.19
Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	1.77	1.71	1.59
Equivalent pounds used by producer plant per electrical horsepower developed at switch board	1.71	1.64	1.53
Equivalent pounds used by producer plant per brake horsepower † available for outside purposes	1.51	1.45	1.35
Equivalent pounds used by producer plant per brake horsepower † developed at engine	1.45	1.40	1.30

Average composition of coal and gas.

COAL.*	Per cent.	GAS BY VOLUME.	Per cent.
Moisture	3.76	Carbon dioxide	8.16
Volatile matter	33.45	Oxygen	.10
Fixed carbon	53.29	Carbon monoxide	16.65
Ash	9.50	Hydrogen	7.20
		Methane	5.64
Sulphur	.86	Nitrogen	62.24
			99.99

The Alabama No. 2 is a clean, hard coal, which was fed in 1 to 1½ inch lumps, and worked well in the producer. It did not cake exces-

† Based on an assumed efficiency of 85 per cent for generator and belt.

* All coal analyses given in this report were made under the direction of Prof. N. W. Lord, and they will appear in his final report.

sively and was easily handled. The greatest trouble in its use aro from its tendency to shrink away from the walls of the producer. was necessary, therefore, to break it against the walls about twi every hour. The lumps did not swell and fuse together, but seem to keep apart in the fire.

COAL, COLORADO NO. 1; PRODUCER-GAS TEST NO. 15.

[Coal from Simpson mine of the Northern Coal and Coke Company, Lafayette, Colo.; tested Decem 13, 14, 1904.]

Duration of test ......hours..	30
Total coal consumed in producer ......pounds..	10,933
Moisture in coal......per cent..	20.
Dry coal consumed in producer......pounds..	8,720
Refuse from dry coal......per cent..	7.
Total refuse from coal......pounds..	640
Total combustible consumed in producer......pounds..	8,080

Coal consumed, pounds per hour.

Coal consumed in producer	364.
Dry coal consumed in producer	290.
Combustible consumed in producer	269.
Equivalent coal used by producer plant......	428.
Equivalent dry coal used by producer plant......	341.
Equivalent combustible used by producer plant	316.

British thermal units.

Per pound of coal as fired......	9,767
Per pound of dry coal	12,245
Per pound of combustible......	13,210
Per cubic foot of standard gas	149
From standard gas, per pound dry coal burned in producer	7,860
From standard gas, per hour per brake horsepower......	9,700

Gas produced, cubic feet (reduced to standard).

Total......	460,300
Per hour......	15,343
Per pound coal consumed in producer	42.
Per pound dry coal consumed in producer	52.
Per pound combustible consumed in producer......	57
Per pound equivalent coal used by producer plant......	35.
Per pound equivalent dry coal used by producer plant	44.
Per pound equivalent combustible used by producer plant	48.

Horsepower developed.

Average electrical horsepower available for outside purposes	186.
Average electrical horsepower developed at switch board	200.
Average brake horsepower † available for outside purposes......	219.
Average brake horsepower † developed at engine	235.

† Based on an assumed efficiency of 85 per cent for generator and belt.

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower available for outside purposes	1.95	1.56	1.45
Per electrical horsepower developed at switch board	1.82	1.45	1.35
Per brake horsepower† available for outside purposes	1.66	1.32	1.23
Per brake horsepower† developed at engine	1.55	1.23	1.14
Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	2.30	1.83	1.70
Equivalent pounds used by producer plant per electrical horsepower developed at switch board	2.14	1.71	1.58
Equivalent pounds used by producer plant per brake horsepower† available for outside purposes	1.95	1.56	1.44
Equivalent pounds used by producer plant per brake horsepower† developed at engine	1.82	1.45	1.34

† Based on an assumed efficiency of 85 per cent for generator and belt.

Average composition of coal and gas.

COAL.	Per cent.	GAS BY VOLUME.	Per cent.
Moisture	20.24	Carbon dioxide	10.11
Volatile matter	32.26	Oxygen	.55
Fixed carbon	41.65	Carbon monoxide	17.38
Ash	5.85	Hydrogen	11.05
		Methane	5.00
Sulphur	.60	Nitrogen	55.90
			99.99

The Colorado No. 1 is a black lignite which clinkered badly in the producer, in spite of frequent poking, but the clinkers were not large and could be broken from the top of the producer. The gas was of a good, uniform quality, and there is no doubt that the fuel can be used to advantage in producers. It yielded a large amount of yellow "lignite tar."

COAL, ILLINOIS NO. 3; PRODUCER-GAS TEST NO. 6.*

[Coal from mine No. 3 of the Southern Illinois Coal Mining and Washing Company, near Marion, Ill.; tested October 31 and November 1, 1904.]

Duration of test	hours	30
Total coal consumed in producer	pounds	10,500
Moisture in coal	per cent	7.62
Dry coal consumed in producer	pounds	9,700
Refuse from dry coal	per cent	10.53
Total refuse from coal	pounds	1,021
Total combustible consumed in producer	do	8,679

* Gas-producer hopper leaked.

Coal consumed, pounds per hour.

Coal consumed in producer	350
Dry coal consumed in producer	323.
Combustible consumed in producer	289.
Equivalent coal used by producer plant	386
Equivalent dry coal used by producer plant	356.7
Equivalent combustible used by producer plant	319.

British thermal units.

Per pound of coal as fired	12,046
Per pound of dry coal	13,041
Per pound of combustible	14,560
Per cubic foot of standard gas	154.
From standard gas per pound dry coal burned in producer	8,330
From standard gas per hour per brake horsepower	11,460

Gas produced, cubic feet (reduced to standard).

Total	522,350
Per hour	17,412
Per pound coal consumed in producer	49.
Per pound dry coal consumed in producer	53.
Per pound combustible consumed in producer	60.
Per pound equivalent coal used by producer plant	45.
Per pound equivalent dry coal used by producer plant	48.
Per pound equivalent combustible used by producer plant	54.

Horsepower developed.

Average electrical horsepower available for outside purposes	192.
Average electrical horsepower developed at switch board	199.
Average brake horsepower † available for outside purposes	226.
Average brake horsepower † developed at engine	235

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Combu-tible.
Per electrical horsepower available for outside purposes	1.82	1.68	1.
Per electrical horsepower developed at switch board	1.75	1.62	1.
Per brake horsepower† available for outside purposes	1.54	1.43	1.
Per brake horsepower† developed at engine	1.49	1.38	1.
Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	2.01	1.85	1.
Equivalent pounds used by producer plant per electrical horsepower developed at switch board	1.93	1.79	1.
Equivalent pounds used by producer plant per brake horsepower† available for outside purposes	1.70	1.58	1.
Equivalent pounds used by producer plant per brake horsepower† developed at engine	1.64	1.52	1.

† Based on an assumed efficiency of 85 per cent for generator and belt.

Average composition of coal and gas.

COAL.	Per cent.	GAS BY VOLUME.	Per cent.
[illegible]oisture	7.62	Carbon dioxide	10.53
[illegible]olatile matter	30.87	Oxygen	.15
[illegible]ixed carbon	51.78	Carbon monoxide	15.31
[illegible]sh	9.73	Hydrogen	8.35
		Methane	4.46
[illegible]ulphur	1.69	Nitrogen	61.19
			99.99

The test on Illinois No. 3 coal was very satisfactory. The gas was [g]ood and the coal easily handled. There were no signs of clinkers in [t]he fire, and it is certain that this coal could be used continuously with-[o]ut trouble from that source. It may be considered a good gas-pro-[d]ucer coal.

COAL, ILLINOIS NO. 4; PRODUCER-GAS TEST NO. 9.*

[Coal from mine No. 3 of the Donk Brothers Coal and Coke Company, Troy, Ill.; tested November 10 and 11, 1904.]

[D]uration of test	hours	30
[T]otal coal consumed in producer	pounds	10,500
[M]oisture in coal	per cent	12.43
[D]ry coal consumed in producer	pounds	9,190
[R]efuse from dry coal	per cent	10.53
[T]otal refuse from coal	pounds	968
[T]otal combustible consumed in producer	do	8,222

Coal consumed, pounds per hour.

[C]oal consumed in producer	350
[D]ry coal consumed in producer	306.3
[C]ombustible consumed in producer	274.1
[E]quivalent coal used by producer plant	398.2
[E]quivalent dry coal used by producer plant	348.5
[E]quivalent combustible used by producer plant	311.9

British thermal units.

[Pe]r pound of coal as fired	11,237
[Pe]r pound of dry coal	12,834
[Pe]r pound of combustible	14,344
[Pe]r cubic foot of standard gas	151.5
[Fr]om standard gas per pound dry coal burned in producer	8,840
[Fr]om standard gas per hour per brake horsepower	11,620

Gas produced, cubic feet (reduced to standard).

[To]tal	536,435
[Pe]r hour	17,881
[Pe]r pound coal consumed in producer	51.1
[Pe]r pound dry coal consumed in producer	58.4
[Pe]r pound combustible consumed in producer	65.3
[Pe]r pound equivalent coal used by producer plant	44.9
[Pe]r pound equivalent dry coal used by producer plant	51.4
[Pe]r pound equivalent combustible used by producer plant	57.4

*Gas-producer hopper leaked.

Horsepower developed.

Average electrical horsepower available for outside purposes	189.
Average electrical horsepower developed at switch board	198.
Average brake horsepower* available for outside purposes	223
Average brake horsepower* developed at engine	233

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Comb tible
Per electrical horsepower available for outside purposes	1.85	1.62	1.
Per electrical horsepower developed at switch board	1.76	1.55	1.
Per brake horsepower* available for outside purposes	1.57	1.37	1
Per brake horsepower* developed at engine	1.50	1.31	1
Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	2.11	1.84	1
Equivalent pounds used by producer plant per electrical horsepower developed at switch board	2.01	1.76	1
Equivalent pounds used by producer plant per brake horsepower* available for outside purposes	1.79	1.56	1
Equivalent pounds used by producer plant per brake horsepower* developed at engine	1.71	1.50	1

Average composition of coal and gas.

COAL.	Per cent.	GAS BY VOLUME.	Per c
Moisture	12.43	Carbon dioxide	9
Volatile matter	32.65	Oxygen	
Fixed carbon	45.70	Carbon monoxide	15
Ash	9.22	Hydrogen	9
		Methane	6
Sulphur	1.41	Nitrogen	59
			100

There was no trouble during the whole of the test of Illinois Nc coal in keeping the producer bed in good condition. The coal yiel a large amount of tar, and gave a rich, uniform gas, which left trace of tar or sulphur in the engine valves. It may be placed amc the better grade of gas-producer coals.

COAL, INDIANA NO. 1; PRODUCER-GAS TEST NO. 14.†

[Coal from Mildred mine of the J. Woolley Coal Company, Mildred, Ind.; tested December 2 an 1904.]

Duration of test	hours	2
Total coal consumed in producer	pounds	11,70
Moisture in coal	per cent	1
Dry coal consumed in producer	pounds	10,36
Refuse from dry coal	per cent	1
Total refuse from coal	pounds	1,18
Total combustible consumed in producer	pounds	9,18

* Based on an assumed efficiency of 85 per cent for generator and belt.

† Gas-producer hopper leaked.

Coal consumed, pounds per hour.

oal consumed in producer	394.5
ry coal consumed in producer	349.3
ombustible consumed in producer	309.5
quivalent coal used by producer plant	434.6
quivalent dry coal used by producer plant	384.8
quivalent combustible used by producer plant	341.0

British thermal units.

er pound of coal as fired	11,534
er pound of dry coal	13,037
er pound of combustible	14,720
er cubic foot of standard gas	153.7
rom standard gas per pound dry coal burned in producer	7,730
rom standard gas per hour per brake horsepower	11,480

Gas produced, cubic feet (reduced to standard).

otal	521,100
er hour	17,560
er pound coal consumed in producer	44.5
er pound dry coal consumed in producer	50.3
er pound combustible consumed in producer	56.7
er pound equivalent coal used by producer plant	40.4
r pound equivalent dry coal used by producer plant	45.6
r pound equivalent combustible used by producer plant	51.5

Horsepower developed.

erage electrical horsepower available for outside purposes	188.3
erage electrical horsepower developed at switch board	199.9
erage brake horsepower* available for outside purposes	221.5
erage brake horsepower* developed at engine	235

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Combustible.
r electrical horsepower available for outside purposes	2.10	1.86	1.64
r electrical horsepower developed at switch board	1.97	1.75	1.55
r brake horsepower* available for outside purposes	1.78	1.58	1.40
r brake horsepower* developed at engine	1.68	1.49	1.32
uivalent pounds used by producer plant per electrical horsepower available for outside purposes	2.31	2.04	1.81
uivalent pounds used by producer plant per electrical horsepower developed at switch board	2.17	1.93	1.71
uivalent pounds used by producer plant per brake horsepower* available for outside purposes	1.96	1.74	1.54
uivalent pounds used by producer plant per brake horsepower* developed at engine	1.85	1.64	1.45

*Based on an assumed efficiency of 85 per cent for generator and belt.

Average composition of coal and gas.

COAL.	Per cent.	GAS BY VOLUME.	Per cent
Moisture	11.51	Carbon dioxide	9.8
Volatile matter	36.04	Oxygen	.2
Fixed carbon	42.37	Carbon monoxide	14.1
Ash	10.08	Hydrogen	9.5
		Methane	6.0
Sulphur	2.61	Nitrogen	60.1
			100.0

The gas from Indiana No. 1 coal was of uniformly good quality. No trouble was experienced in working the bed, and the coal may be considered an excellent producer fuel. It yielded a fair amount of good black tar.

COAL, INDIANA NO. 2; PRODUCER-GAS TEST NO. 13.*

[Coal from Electric mine of the T. D. Scales Coal Company, Boonville, Ind.; tested November 28 an 29, 1904.]

Duration of test ....hours..	7
Total coal consumed in producer ....pounds..	2,100
Moisture in coal ....per cent..	8.7
Dry coal consumed in producer ....pounds..	1,917
Refuse from dry coal ....per cent..	10.6
Total refuse from coal ....pounds..	204.3
Total combustible consumed in producer ....do....	1,712.7

Coal consumed, pounds per hour.

Coal consumed in producer	300
Dry coal consumed in producer	274
Combustible consumed in producer	244.8
Equivalent coal used by producer plant	338
Equivalent dry coal used by producer plant	312
Equivalent conbustible used by producer plant	278.8

British thermal units.

Per pound of coal as fired	11,822
Per pound of dry coal	12,953
Per pound of combustible	14,500
Per cubic foot of standard gas	159.
From standard gas per pound dry coal burned in producer	10,140
From standard gas per hour per brake horsepower	11,750

Gas produced, cubic feet (reduced to standard).

Total	122,160
Per hour	17,450
Per pound coal consumed in producer	58.
Per pound dry coal consumed in producer	63.
Per pound combustible consumed in producer	71.
Per pound equivalent coal used by producer plant	51.
Per pound equivalent dry coal used by producer plant	55.
Per pound equivalent combustible used by producer plant	62.

* Gas-producer hopper leaked.

Horsepower developed.

verage electrical horsepower available for outside purposes	191.4
verage electrical horsepower developed at switch board	201
verage brake horsepower† available for outside purposes	225
verage brake horsepower† developed at engine	236.5

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Combustible.
r electrical horsepower available for outside purposes	1.57	1.43	1.28
r electrical horsepower developed at switch board	1.49	1.36	1.22
r brake horsepower† available for outside purposes	1.33	1.22	1.09
r brake horsepower† developed at engine	1.27	1.16	1.03
uivalent pounds used by producer plant per electrical horsepower available for outside purposes	1.77	1.63	1.46
uivalent pounds used by producer plant per electrical horsepower developed at switch board	1.68	1.55	1.39
uivalent pounds used by producer plant per brake horsepower† available for outside purposes	1.52	1.39	1.24
uivalent pounds used by producer plant per brake horsepower† developed at engine	1.43	1.32	1.18

Average composition of coal and gas.

COAL.	Per cent.	GAS BY VOLUME.	Per cent.
isture	8.72	Carbon dioxide	11.80
latile matter	39.60	Oxygen	.07
ed carbon	41.95	Carbon monoxide	11.46
h	9.73	Hydrogen	10.60
		Methane	6.10
phur	4.23	Nitrogen	59.97
			100.00

The Indiana No. 2 coal did not yield particularly good results during e test. The gas produced from it was difficult to clean and conned a high percentage of sulphur. During the first part of the test e gas was low in heat value, but improved in quality after the fuel l had been increased in depth. This shows that good results may obtained from this coal if it is properly fired in the producer, and adequate facilities are provided for scrubbing and purifying the gas.

† Based on an assumed efficiency of 85 per cent for generator and belt.

COAL, INDIAN TERRITORY NO. 1, PRODUCER-GAS TEST NO. 1.

[Coal from mine No. 1 of the Whitehead Coal and Mining Company, Henryetta, Ind. T.; tes
October 3, 4, 5, and 6, 1904.]

Duration of test .... hours..	31
Total coal produced in producer .... pounds..	11,200
Moisture in coal .... per cent..	5
Dry coal consumed in producer .... pounds..	10,640
Refuse from dry coal .... per cent..	8.
Total refuse from coal .... pounds..	955
Total combustible consumed in producer .... do....	9,685

Coal consumed, pounds per hour.

Coal consumed in producer	361
Dry coal consumed in producer	344
Combustible consumed in producer	312
Equivalent coal used by producer plant	392
Equivalent dry coal used by producer plant	374
Equivalent combustible used by producer plant	339.

British thermal units.

Per pound of coal	12,787
Per pound of dry coal	13,455
Per pound of combustible	14,800
Per cubic feet of standard gas	159.
From standard gas per pound dry coal burned in producer	8,620
From standard gas per hour per brake horsepower	12,350

Gas produced, cubic feet (reduced to standard).

Total	577,000
Per hour	18,613
Per pound coal consumed in producer	51.
Per pound dry coal consumed in producer	54.
Per pound combustible consumed in producer	59.
Per pound equivalent coal used by producer plant	47.
Per pound equivalent dry coal used by producer plant	49.
Per pound equivalent combustible used by producer plant	54.

Horsepower developed.

Average electrical horsepower available for outside purposes	196
Average electrical horsepower developed at switch board	204
Average brake horsepower † available for outside purposes	230
Average brake horsepower † developed at engine	240

† Based on an assumed efficiency of 85 per cent for generator and belt.

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Combustible.
r electrical horsepower available for outside purposes	1.84	1.76	1.59
r electrical horsepower developed at switch board	1.77	1.69	1.53
r brake horsepower† available for outside purposes	1.57	1.50	1.36
r brake horsepower† developed at engine	1.50	1.43	1.30
uivalent pounds used by producer plant per electrical horsepower available for outside purposes	2.00	1.91	1.73
uivalent pounds used by producer plant per electrical horsepower developed at switch board	1.92	1.83	1.66
uivalent pounds used by producer plant per brake horsepower† available for outside purposes	1.71	1.62	1.47
uivalent pounds used by producer plant per brake horsepower† developed at engine	1.64	1.56	1.41

†Based on an assumed efficiency of 85 per cent for generator and belt.

Average composition of coal and gas.

COAL.	Per cent.	GAS BY VOLUME.	Per cent.
isture	5.00	Carbon dioxide	8.25
latile matter	36.51	Oxygen	.11
ed carbon	49.98	Carbon monoxide	19.39
h	8.51	Hydrogen	7.69
		Methane	4.92
phur	1.43	Nitrogen	59.65
			100.01

Indian Territory coal No. 1 is a moderately free-burning coal. It ked fairly well in the producer and made a good top crust, which s easily worked. It was charged into the producer after being ished and screened over a half-inch screen. This was done while it s wet, and considerable slack was carried over with the lumps. This coal may be considered a good producer coal.

COAL, KENTUCKY NO. 3; PRODUCER-GAS TEST NO. 12.*

l from Barnsley mine of the St. Bernard Mining Company, Earlington, Ky.; tested November 25 and 26, 1904.]

ation of test	hours	30
al coal consumed in producer	pounds	11,100
sture in coal	per cent	7.28
coal consumed in producer	pounds	10,300
use from dry coal	per cent	9.69
al refuse from coal	pounds	1,000
al combustible consumed in producer	do	9,300

*Gas-producer hopper leaked.

Coal consumed, pounds per hour.

Coal consumed in producer	370
Dry coal consumed in producer	343.
Combustible consumed in producer	310
Equivalent coal used by producer plant	410.
Equivalent dry coal used by producer plant	381.
Equivalent combustible used by producer plant	344.

British thermal units.

Per pound of coal as fired	12,283
Per pound of dry coal	13,226
Per pound of combustible	14,650
Per cubic foot of standard gas	155.
From standard gas per pound dry coal burned in producer	8,610
From standard gas per hour per brake horsepower	12,540

Gas produced, cubic feet (reduced to standard).

Total	568,295
Per hour	18,943
Per pound coal consumed in producer	51.
Per pound dry coal consumed in producer	55.
Per pound combustible consumed in producer	61.
Per pound equivalent coal used by producer plant	46.
Per pound equivalent dry coal used by producer plant	49.
Per pound equivalent combustible used by producer plant	55

Horsepower developed.

Average electrical horsepower available for outside purposes	189.
Average electrical horsepower developed at switch board	200.
Average brake horsepower† available for outside purposes	223.
Average brake horsepower† developed at engine	235.

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Comb tibl
Per electrical horsepower available for outside purposes	1.95	1.81	1
Per electrical horsepower developed at switch board	1.85	1.71	1
Per brake horsepower † available for outside purposes	1.66	1.54	1
Per brake horsepower † developed at engine	1.57	1.46	1
Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	2.16	2.01	1
Equivalent pounds used by producer plant per electrical horsepower developed at switch board	2.05	1.91	1
Equivalent pounds used by producer plant per brake horsepower† available for outside purposes	1.84	1.71	1
Equivalent pounds used by producer plant per brake horsepower† developed at engine	1.75	1.62	1

†Based on an assumed efficiency of 85 per cent for generator and belt.

Average composition of coal and gas.

COAL.	Per cent.	GAS BY VOLUME.	Per cent.
isture	7.28	Carbon dioxide	10.87
latile matter	38.57	Oxygen	.29
ced carbon	45.16	Carbon monoxide	12.45
h	8.99	Hydrogen	10.92
		Methane	6.52
phur	3.86	Nitrogen	58.95
			100.00

The Kentucky No. 3 is a hard bituminous coal and burned in the oducer with a hard top crust. It yielded good gas of uniform ality and clean black tar. It is well adapted for producer gas.

COAL, MISSOURI NO. 2; PRODUCER-GAS TEST NO. 7.*

ıl from mine No. 8 of the Northwestern Coal and Mining Company, Bevier, Mo.; tested November 3, 1904.]

ration of test	hours	4.33
al coal consumed in producer	pounds	1,500
isture in coal	per cent	11.6
coal consumed in producer	pounds	1,326
use from dry coal	per cent	16.79
al refuse from coal	pounds	223
al combustible consumed in producer	do	1,103

Coal consumed, pounds per hour.

l consumed in producer	346.5
coal consumed in producer	306
ıbustible consumed in producer	255
ıivalent coal used by producer plant	384.5
ıivalent dry coal used by producer plant	339.6
ıivalent combustible used by producer plant	283

British thermal units.

pound of coal as fired	10,505
pound of dry coal	11,882
pound of combustible	14,280
cubic foot of standard gas	140
m standard gas per pound dry coal burned in producer	8,820
m standard gas per hour per brake horsepower	11,560

Gas produced, cubic feet (reduced to standard).

al	83,545
hour	19,300
pound coal consumed in producer	55.7
pound dry coal consumed in producer	63
pound combustible consumed in producer	75.7
pound equivalent coal used by producer plant	50.2
pound equivalent dry coal used by producer plant	56.8
pound equivalent combustible used by producer plant	68.2

* Gas-producer hopper leaked.

Horsepower developed.

Average electrical horsepower available for outside purposes	185.7
Average electrical horsepower developed at switch board	198.6
Average brake horsepower † available for outside purposes	218.5
Average brake horsepower † developed at engine	233.5

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower available for outside purposes	1.87	1.65	1.3
Per electrical horsepower developed at switch board	1.74	1.54	1.2
Per brake horsepower † available for outside purposes	1.59	1.40	1.1
Per brake horsepower † developed at engine	1.48	1.31	1.0
Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	2.07	1.83	1.5
Equivalent pounds used by producer plant per electrical horsepower developed at switch board	1.94	1.71	1.4
Equivalent pounds used by producer plant per brake horsepower † available for outside purposes	1.76	1.55	1.3
Equivalent pounds used by producer plant per brake horsepower † developed at engine	1.65	1.45	1.2

Average composition of coal and gas.

COAL.	Per cent.	GAS BY VOLUME.	Per cent.
Moisture	11.60	Carbon dioxide	12.0
Volatile matter	35.28	Oxygen	.2
Fixed carbon	38.28	Carbon monoxide	10.5
Ash	14.84	Hydrogen	7.6
		Methane	6.3
Sulphur	4.56	Nitrogen	63.2
			99.9

In using Missouri No. 2 coal some difficulty was experienced in keeping the bed in good condition, owing to its tendency to break open in spots. The high percentage of sulphur in the coal did not add to its value as a producer fuel, but the writer's opinion is that it can be used to advantage in producers by increasing the facilities for purifying.

COAL, MONTANA NO. 1; PRODUCER-GAS TEST NO. 5.*

[Coal from mine near Red Lodge, Mont.; tested October 24–25, 1904.]

Duration of test	hours	22.3
Total coal consumed in producer	pounds	10,200
Moisture in coal	per cent	11.4
Dry coal consumed in producer	pounds	9,037
Refuse from dry coal	per cent	12.1
Total refuse from coal	pounds	1,095
Total combustible consumed in producer	do	7,942

* Gas-producer hopper leaked.

† Based on an assumed efficiency of 85 per cent for generator and belt.

Coal consumed, pounds per hour.

oal consumed in producer	456.5
ry coal consumed in producer	404.5
ombustible consumed in producer	355.8
quivalent coal used by producer plant	506.8
quivalent dry coal used by producer plant	449.1
quivalent combustible used by producer plant	395

British thermal units.

er pound of coal as fired	10,575
er pound of dry coal	11,934
er pound of combustible	13,580
er cubic foot of standard gas	160.8
om standard gas per pound of dry coal burned in producer	6,580
om standard gas per hour per brake horsepower	11,340

Gas produced, cubic feet (reduced to standard).

otal	369,500
r hour	16,540
r pound coal consumed in producer	36.23
r pound dry coal consumed in producer	40.89
r pound combustible consumed in producer	46.50
r pound equivalent coal used by producer plant	32.64
r pound equivalent dry coal used by producer plant	36.80
r pound equivalent combustible used by producer plant	41.90

Horsepower developed.

erage electrical horsepower available for outside purposes	191
erage electrical horsepower developed at switchboard	199.5
erage brake horsepower † available for outside purposes	224.8
erage brake horsepower † developed at engine	234.7

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Combustible.
electrical horsepower available for outside purposes	2.39	2.12	1.86
electrical horsepower developed at switch board	2.29	2.03	1.78
brake horsepower † available for outside purposes	2.03	1.80	1.58
brake horsepower † developed at engine	1.95	1.72	1.52
uivalent pounds used by producer plant per electrical orsepower available for outside purposes	2.65	2.35	2.07
uivalent pounds used by producer plant per electrical orsepower developed at switch board	2.54	2.25	1.98
uivalent pounds used by producer plant per brake orsepower † available for outside purposes	2.26	2.00	1.76
uivalent pounds used by producer plant per brake orsepower † developed at engine	2.16	1.91	1.68

† Based on an assumed efficiency of 85 per cent for generator and belt.

Average composition of coal and gas.

COAL.	Per cent.	GAS BY VOLUME.	Per cent.
Moisture	11.40	Carbon dioxide	9.04
Volatile matter	34.55	Oxygen	.36
Fixed carbon	43.31	Carbon monoxide	18.67
Ash	10.74	Hydrogen	8.00
		Methane	4.84
Sulphur	1.72	Nitrogen	59.10
			100.01

The Montana No. 1 coal was a washed slack. It made good gas, but was too fine to be burned at the rated output of the producer. It clinkered badly, causing the blast to break through the bed in two or three places and make bad holes. The test is valuable principally as a demonstration that good gas can be made from coal of this class.

It is recommended that a water seal type of producer be used for fuel of this class, and also that the coal be fed in sizes not smaller than chestnut. In using lump coal the producer should be 20 per cent larger for the same horsepower than one running on ordinary coal; and for slack from 25 to 30 per cent larger.

After this test the bed of ashes was drawn from the producer, as the large clinkers would have been detrimental to the next following test.

COAL, NORTH DAKOTA NO. 2; PRODUCER-GAS TEST NO. 10.*

[Coal from the mine of the Cedar Coulee Coal Company, near Williston, N. Dak.; tested November 14, 15, 1904.]

Duration of test	hours	30
Total coal consumed in producer	pounds	13,800
Moisture in coal	per cent	39.56
Dry coal consumed in producer	pounds	8,340
Refuse from dry coal	per cent	10.53
Total refuse from coal	pounds	878
Total combustible consumed in producer	do	7,462

Coal consumed, pounds per hour.

Coal consumed in producer	460
Dry coal consumed in producer	278
Combustible consumed in producer	249
Equivalent coal used by producer plant	510
Equivalent dry coal used by producer plant	308
Equivalent combustible used by producer plant	275.8

British thermal units.

Per pound of coal as fired	6,802
Per pound of dry coal	11,255
Per pound of combustible	12,600
Per cubic foot of standard gas	188.5
From standard gas per pound dry coal burned in producer	7,830
From standard gas per hour per brake horsepower	13,770

*Gas-producer hopper leaked.

Gas produced, cubic feet (reduced to standard).

otal	346,400
er hour	11,550
er pound coal consumed in producer	25.15
er pound dry coal consumed in producer	41.53
er pound combustible consumed in producer	46.42
er pound equivalent coal used by producer plant	22.68
er pound equivalent dry coal used by producer plant	37.5
er pound equivalent combustible used by producer plant	41.88

Horsepower developed.

verage electrical horsepower available for outside purposes	125.1
verage electrical horsepower developed at switch board	134.2
verage brake horsepower† available for outside purposes	147.3
verage brake horsepower† developed at engine	158

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Combustible.
er electrical horsepower available for outside purposes	3.67	2.22	1.99
er electrical horsepower developed at switch board	3.42	2.07	1.86
er brake horsepower † available for outside purposes	3.13	1.89	1.69
er brake horsepower † developed at engine	2.91	1.76	1.58
quivalent pounds used by producer plant per electrical horsepower available for outside purposes	4.07	2.46	2.20
quivalent pounds used by producer plant per electrical horsepower developed at switch board	3.80	2.29	2.05
quivalent pounds used by producer plant per brake horsepower † available for outside purposes	3.47	2.09	1.88
quivalent pounds used by producer plant per brake horsepower † developed at engine	3.23	1.95	1.74

Average composition of coal and gas.

COAL.	Per cent.	GAS BY VOLUME.	Per cent.
oisture	39.56	Carbon dioxide	8.69
olatile matter	27.78	Oxygen	.23
xed carbon	26.30	Carbon monoxide	20.90
h	6.36	Hydrogen	14.33
		Methane	4.85
lphur	.93	Nitrogen	51.02
			100.02

This brown lignite would be an ideal gas-producer fuel but for its ndency to clinker. It yielded a rich gas and not so very much tar. his tar was yellow and sticky and not at all like that from bitumius coal. The bed had to be carried deeper than for soft coal and had be poked frequently to prevent the formation of clinkers. After

† Based on an assumed efficiency of 85 per cent for generator and belt.

thirty hours' continuous run the bed was in good condition, and the test could have been continued or a new run begun without renewing the producer bed.

During the test the engine carried only two-thirds of its normal load, but there seems to be no doubt that it could have carried full load throughout the entire run.

COAL, TEXAS NO. 1; PRODUCER-GAS TEST NO. 11.*

[Coal from the mine of the Houston County Coal and Manufacturing Company, near Crockett, Tex.; tested November 21, 22, 1904.]

Duration of test........hours..	21.67
Total coal consumed in producer........pounds..	12,800
Moisture in coal........per cent..	33.50
Dry coal consumed in producer........pounds..	8,510
Refuse from dry coal........per cent..	15.85
Total refuse from coal........pounds..	1,327
Total combustible consumed in producer........do....	7,183
Coal consumed, pounds per hour.	
Coal consumed in producer........	590
Dry coal consumed in producer........	393
Combustible consumed in producer........	332
Equivalent coal used by producer plant........	660
Equivalent dry coal used by producer plant........	439.5
Equivalent combustible used by producer plant........	371.3
British thermal units.	
Per pound of coal as fired........	7,267
Per pound of dry coal........	10,928
Per pound of combustible........	12,945
Per cubic foot of standard gas........	169.7
From standard gas per pound dry coal burned in producer........	7,260
From standard gas per hour per brake horsepower........	12,230
Gas produced, cubic feet (reduced to standard).	
Total........	363,654
Per hour........	16,800
Per pound coal consumed in producer........	28.4
Per pound dry coal consumed in producer........	42.7
Per pound combustible consumed in producer........	50.6
Per pound equivalent coal used by producer plant........	25.5
Per pound equivalent dry coal used by producer plant........	38.2
Per pound equivalent combustible used by producer plant........	45.3
Horsepower developed.	
Average electrical horsepower available for outside purposes........	187
Average electrical horsepower developed at switch board........	198
Average brake horsepower † available for outside purposes........	220
Average brake horsepower † developed at engine........	233

* Gas-producer hopper leaked.

† Based on an assumed efficiency of 85 per cent for generator and belt.

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Combustible.
r electrical horsepower available for outside purposes..	3.16	2.10	1.78
r electrical horsepower developed at switch board.....	2.98	1.99	1.68
r brake horsepower † available for outside purposes ...	2.68	1.79	1.51
r brake horsepower † developed at engine	2.54	1.69	1.43
uivalent pounds used by producer plant per electrical horsepower available for outside purposes............	3.53	2.35	1.99
uivalent pounds used by producer plant per electrical horsepower developed at switch board................	3.34	2.22	1.88
uivalent pounds used by producer plant per brake horsepower † available for outside purposes	3.00	2.20	1.69
uivalent pounds used by producer plant per brake horsepower † developed at engine	2.83	1.99	1.60

† Based on an assumed efficiency of 85 per cent for generator and belt.

Average composition of coal and gas.

COAL.	Per cent.	GAS BY VOLUME.	Per cent.
oisture	33.50	Carbon dioxide	11.10
latile matter	32.34	Oxygen	.22
xed carbon	23.80	Carbon monoxide	14.43
h	10.36	Hydrogen	10.54
		Methane	7.48
lphur	.63	Nitrogen	56.22
			99.99

The Texas No. 1 is a brown lignite strongly resembling that pre- ously tested from North Dakota. The gas from it was not so rich that from the North Dakota lignite, but it was higher in heat units an is the gas obtained from ordinary soft coal. The lignite was ore difficult to handle in the producer than bituminous coal, but frequent poking and by supplying the right amount of air to the oducer the bed was kept in good condition, and at the end of the irty-hour test it was possible to break up the clinkers in the bed, quiring the removal of only a few ashes before beginning a new st. This lignite yielded a large amount of tar of the same kind as e lignite previously tested. As a producer fuel it is better than any grades of bituminous coal.

COAL, TEXAS NO. 2; PRODUCER-GAS TEST NO. 18.

[Coal from Consumers Lignite Company, Hoyt, Tex.; tested December 21, 22, 1904.]

ration of test	hours..	19.33
tal coal consumed in producer	pounds..	9,050
isture in coal	per cent..	33.71
y coal consumed in producer	pounds..	5,999
fuse from dry coal	per cent..	10.98
tal refuse from coal	pounds..	658.7
tal combustible consumed in producer	do....	5,340.3

Coal consumed, pounds per hour.

Coal consumed in producer	468
Dry coal consumed in producer	310.3
Combustible consumed in producer	276.2
Equivalent coal used by producer plant	519.5
Equivalent dry coal used by producer plant	344.4
Equivalent combustible used by producer plant	306.6

British thermal units.

Per pound of coal as fired	7,348
Per pound of dry coal	11,086
Per pound of combustible	12,450
Per cubic foot of standard gas	156.2
From standard gas per pound dry coal burned in producer	8,060
From standard gas per hour per brake horsepower	10,570

Gas produced, cubic feet (reduced to standard).

Total	309,140
Per hour	16,009
Per pound coal consumed in producer	34.2
Per pound dry coal consumed in producer	51.6
Per pound combustible consumed in producer	57.9
Per pound equivalent coal used by producer plant	30.8
Per pound equivalent dry coal used by producer plant	46.4
Per pound equivalent combustible used by producer plant	52.2

Horsepower developed.

Average electrical horsepower available for outside purposes	189.6
Average electrical horsepower developed at switch board	201.2
Average brake horsepower † available for outside purposes	223
Average brake horsepower † developed at engine	236.5

Coal consumed, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower available for outside purposes	2.47	1.64	1.46
Per electrical horsepower developed at switch board	2.33	1.54	1.37
Per brake horsepower † available for outside purposes	2.10	1.39	1.24
Per brake horsepower † developed at engine	1.98	1.31	1.17
Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	2.74	1.82	1.62
Equivalent pounds used by producer plant per electrical horsepower developed at switch board	2.58	1.71	1.52
Equivalent pounds used by producer plant per brake horsepower † available for outside purposes	2.33	1.55	1.38
Equivalent pounds used by producer plant per brake horsepower † developed at engine	2.20	1.46	1.30

† Based on an assumed efficiency of 85 per cent for generator and belt.

Average composition of coal and gas.

COAL.	Per cent.	GAS BY VOLUME.	Per cent.
Ioisture	33.71	Carbon dioxide	9.60
'olatile matter	29.25	Oxygen	.20
'ixed carbon	29.76	Carbon monoxide	18.22
sh	7.28	Hydrogen	9.63
		Methane	4.81
ulphur	.53	Nitrogen	57.53
			99.99

Texas No. 2 is a brown lignite that gave highly satisfactory results n the producer, yielding a rich, uniform gas and a large amount of ellow tar. It is an excellent fuel for producers.

COAL, WEST VIRGINIA NO. 1; PRODUCER-GAS TEST NO. 3.

Coal from the mine of the Virginia and Pittsburg Coal Company, Kingmont, W. Va.; tested October 17, 18, 1904.]

uration of test	hours..	24
otal coal consumed in producer	pounds..	6,900
Ioisture in coal	per cent..	1.61
ry coal consumed in producer	pounds..	6,790
efuse from dry coal	per cent..	6.24
otal refuse from coal	pounds..	423.5
otal combustible consumed in producer	do....	6,366.5

Coal consumed, pounds per hour.

oal consumed in producer	287.5
ry coal consumed in producer	283
ombustible consumed in producer	265.5
quivalent coal used by producer plant	320.6
quivalent dry coal used by producer plant	315.6
quivalent combustible used by producer plant	296.1

British thermal units.

er pound of coal	14,166
er pound of dry coal	14,396
er pound of combustible	15,350
er cubic foot of standard gas	144.4
rom standard gas per pound dry coal burned in producer	9,260
rom standard gas per hour per brake horsepower	11,130

Gas produced, cubic feet (reduced to standard).

otal	435,500
er hour	18,150
er pound coal consumed in producer	63.2
er pound dry coal consumed in producer	64.1
er pound combustible consumed in producer	68.4
er pound equivalent coal used by producer plant	56.6
er pound equivalent dry coal used by producer plant	57.5
er pound equivalent combustible used by producer plant	61.3

Horsepower developed.

Average electrical horsepower available for outside purposes	190.1
Average electrical horsepower developed at switchboard	200.4
Average brake horsepower† available for outside purposes	223.8
Average brake horsepower† developed at engine	235.5

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower available for outside purposes	1.51	1.49	1.4
Per electrical horsepower developed at switch board	1.43	1.41	1.3
Per brake horsepower† available for outside purposes	1.29	1.27	1.1
Per brake horsepower† developed at engine	1.22	1.20	1.1
Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	1.69	1.66	1.5
Equivalent pounds used by producer plant per electrical horsepower developed at switch board	1.60	1.57	1.4
Equivalent pounds used by producer plant per brake horsepower † available for outside purposes	1.43	1.41	1.3
Equivalent pounds used by producer plant per brake horsepower †developed at engine	1.36	1.34	1.2

Average composition of coal and gas.

COAL.	Per cent.	GAS BY VOLUME.	Per cent
Moisture	1.61	Carbon dioxide	10.5
Volatile matter	36.85	Oxygen	.1
Fixed carbon	55.40	Carbon monoxide	14.3
Ash	6.14	Hydrogen	2.8
		Methane	5.5
Sulphur	.87	Nitrogen	66.6
			100.0

Previous to starting the test on this coal the tar extractor was remove and a new one substituted. As it was necessary to take the produce operator from his work to assist in placing the new extractor, the pro ducer did not receive any attention for a few days and was in bad con dition when the test was started. It was thought best to see if th producer could be made to carry full load and build up its bed int good running condition at the same time. The load was carried an the producer was in good shape for the official test six hours afte being put into operation.

As the coal contained about 50 per cent slack, the producer was ru with a hot bed, in order to coke the coal quickly after it fell on th fire. It made a good top coke, which was readily handled. The fi was easily managed and the coal may be considered an excellent fu for producers.

† Based on an assumed efficiency of 85 per cent for generator and belt.

COAL, WEST VIRGINIA NO. 4; PRODUCER-GAS TEST NO. 4.

[Coal from the mine of the West Virginia Coal Company, Bretz, W. Va.; tested October 20, 1904.]

Duration of test ....hours..	9
Total coal consumed in producer ....pounds..	2,100
Moisture in coal ....per cent..	1.99
Dry coal consumed in producer ....pounds..	2,058.2
Refuse from dry coal ....per cent..	9
Total refuse from coal ....pounds..	184.9
Total combustible consumed in producer ....pounds..	1,873.3

Coal consumed, pounds per hour.

Coal consumed in producer	233
Dry coal consumed in producer	229
Combustible consumed in producer	208
Equivalent coal used by producer plant	262.8
Equivalent dry coal used by producer plant	258.2
Equivalent combustible used by producer plant	234.5

British thermal units.

Per pound of coal	13,918
Per pound of dry coal	14,202
Per pound of combustible	15,600
Per cubic foot of standard gas	143.2
From standard gas per pound dry coal burned in producer	11,610
From standard gas per hour per brake horsepower	11,320

Gas produced, cubic feet (reduced to standard).

Total	167,000
Per hour	18,560
Per pound coal consumed in producer	79.6
Per pound dry coal consumed in producer	81.2
Per pound combustible consumed in producer	89.2
Per pound equivalent coal used by producer plant	70.6
Per pound equivalent dry coal used by producer plant	71.9
Per pound equivalent combustible used by producer plant	79.2

Horsepower developed.

Average electrical horsepower available for outside purposes	189.2
Average electrical horsepower developed at switch board	199.7
Average brake horsepower† available for outside purposes	222.5
Average brake horsepower† developed at engine	235

† Based on an assumed efficiency of 85 per cent for generator and belt.

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Combustible.
Per electrical horsepower available for outside purposes	1.23	1.21	1.10
Per electrical horsepower developed at switch board	1.17	1.15	1.04
Per brake horsepower † available for outside purposes	1.05	1.03	.93[illegible]
Per brake horsepower † developed at engine	.992	.975	.88[illegible]
Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	1.39	1.36	1.24
Equivalent pounds used by producer plant per electrical horsepower developed at switch board	1.32	1.29	1.17
Equivalent pounds used by producer plant per brake horsepower † available for outside purposes	1.18	1.16	1.05
Equivalent pounds used by producer plant per brake horsepower † developed at engine	1.12	1.10	.99[illegible]

† Based on an assumed efficiency of 85 per cent for generator and belt.

Average composition of coal and gas.

COAL.	Per cent.	GAS BY VOLUME.	Per cent.
Moisture	1.99	Carbon dioxide	10.1[illegible]
Volatile matter	28.89	Oxygen	.2[illegible]
Fixed carbon	60.30	Carbon monoxide	15.8[illegible]
Ash	8.82	Hydrogen	11.1[illegible]
		Methane	3.7[illegible]
Sulphur	.79	Nitrogen	58.8[illegible]
			100.0[illegible]

The West Virginia No. 4 coal is soft and friable, reaching the producer mainly as slack. It coked well on top of the bed and was readily worked. It promised to give the largest yield of gas of all the coals used thus far. Owing to the small supply of coal available the test was necessarily of short duration, but enough was done to show that it is an excellent gas-producer coal.

COAL, WEST VIRGINIA NO. 9, PRODUCER-GAS TEST NO. 17.

[Coal from Vulcan mine of the Mount Carbon Coal Company (Limited), Powellton, W. Va.; teste[illegible] December, 19, 1904.]

Duration of test	hours..	6.[illegible]
Total coal consumed in producer	pounds..	1,900
Moisture in coal	per cent..	2.[illegible]
Dry coal consumed in producer	pounds..	1,848
Refuse from dry coal	per cent..	5.[illegible]
Total refuse from coal	pounds..	108.[illegible]
Total combustible consumed in producer	pounds..	1,739.[illegible]

Coal consumed, pounds per hour.

Coal consumed in producer	300
Dry coal consumed in producer	292
Combustible consumed in producer	274.[illegible]
Equivalent coal used by producer plant	328.[illegible]
Equivalent dry coal used by producer plant	320.[illegible]
Equivalent combustible used by producer plant	301.[illegible]

British thermal units.

er pound of coal as fired	14,195
er pound of dry coal	14,580
er pound of combustible	15,500
er cubic foot of standard gas	151
rom standard gas per pound, dry coal burned in producer	8,150
rom standard gas per hour per brake horsepower	10,060

Gas produced, cubic feet (reduced to standard).

otal	99,781
er hour	15,770
er pound coal consumed in producer	52.6
er pound dry coal consumed in producer	54
er pound combustible consumed in producer	57.4
er pound equivalent coal used by producer plant	48
er pound equivalent dry coal used by producer plant	49.3
er pound equivalent combustible used by producer plant	52.3

Horsepower developed.

verage electrical horsepower available for outside purposes	186.9
verage electrical horsepower developed at switch board	201
verage brake horsepower † available for outside purposes	220
verage brake horsepower † developed at engine	236.5

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Combustible.
r electrical horsepower available for outside purposes	1.60	1.56	1.47
r electrical horsepower developed at switch board	1.49	1.46	1.37
r brake horsepower † available for outside purposes	1.36	1.33	1.25
r brake horsepower † developed at engine	1.27	1.24	1.16
uivalent pounds used by producer plant per electrical horsepower available for outside purposes	1.76	1.71	1.61
uivalent pounds used by producer plant per electrical horsepower developed at switch board	1.64	1.59	1.50
uivalent pounds used by producer plant per brake horsepower † available for outside purposes	1.49	1.46	1.37
uivalent pounds used by producer plant per brake horsepower † developed at engine	1.39	1.35	1.27

Average composition of coal and gas.

COAL.	Per cent.	GAS BY VOLUME.	Per cent.
oisture	2.66	Carbon dioxide	10.40
latile matter	32.00	Oxygen	.20
ed carbon	59.61	Carbon monoxide	13.70
h	5.73	Hydrogen	9.55
		Methane	6.60
phur	1.00	Nitrogen	59.55
			100.00

† Based on an assumed efficiency of 85 per cent for generator and belt.

The West Virginia No. 9 is a rich bituminous coal. It burned well and was easily handled in the producer, yielding a gas of uniformly good quality. It makes a good producer fuel. On account of an accident to the gas engine the test on this coal had to be stopped before it was completed. A second test is being made as this report goes to press. The results of the second test will be given in the final report.

COAL, WEST VIRGINIA NO. 12, PRODUCER-GAS TEST NO. 8.*

[Coal from mine of the Big Sandy Coal and Coke Company, Big Sandy, W. Va.; tested November 7, 8, 1904.]

Duration of test	hours	30
Total coal consumed in producer	pounds	8,100
Moisture in coal	per cent	1.43
Dry coal consumed in producer	pounds	7,984
Refuse from dry coal	per cent	6.54
Total refuse from coal	pounds	522
Total combustible consumed in producer	do	7,462

Coal consumed, pounds per hour.

Coal consumed in producer	270
Dry coal consumed in producer	266.1
Combustible consumed in producer	248.7
Equivalent coal used by producer plant	304.9
Equivalent dry coal used by producer plant	300.5
Equivalent combustible used by producer plant	280.9

British thermal units.

Per pound of coal as fired	14,614
Per pound of dry coal	14,825
Per pound of combustible	15,860
Per cubic foot of standard gas	142.[illegible]
From standard gas per pound dry coal burned in producer	10,150
From standard gas per hour per brake horsepower	11,500

Gas produced, cubic feet (reduced to standard).

Total	568,700
Per hour	18,957
Per pound coal consumed in producer	70.[illegible]
per pound dry coal consumed in producer	71.[illegible]
Per pound combustible consumed in producer	76.[illegible]
Per pound equivalent coal used by producer plant	62.[illegible]
Per pound equivalent dry coal used by producer plant	63.[illegible]
Per pound equivalent combustible used by producer plant	67.[illegible]

Horsepower developed.

Average electrical horsepower available for outside purposes	191.[illegible]
Average electrical horsepower developed at switch board	199.[illegible]
Average brake horsepower † available for outside purposes	225
Average brake horsepower † developed at engine	235

* Gas-producer hopper leaked.

† Based on an assumed efficiency of 85 per cent for generator and belt.

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Combustible.
er electrical horsepower available for outside purposes..	1.41	1.39	1.30
er electrical horsepower developed at switch board.....	1.35	1.33	1.24
er brake horsepower† available for outside purposes	1.20	1.18	1.11
er brake horsepower† developed at engine	1.15	1.13	1.06
quivalent pounds used by producer plant per electrical horsepower available for outside purposes..............	1.59	1.57	1.47
quivalent pounds used by producer plant per electrical horsepower developed at switch board.................	1.53	1.50	1.40
quivalent pounds used by producer plant per brake horsepower † available for outside purposes	1.35	1.34	1.25
quivalent pounds used by producer plant per brake horsepower† developed at engine	1.30	1.28	1.20

† Based on an assumed efficiency of 85 per cent for generator and belt.

Average composition of coal and gas.

COAL.	Per cent.	GAS BY VOLUME.	Per cent.
oisture..........................	1.43	Carbon dioxide	10.34
olatile matter...................	18.93	Oxygen	.12
ixed carbon	73.19	Carbon monoxide	14.21
sh	6.45	Hydrogen	12.98
		Methane	4.61
ılphur...........................	.95	Nitrogen.......................	57.75
			100.01

The West Virginia No. 12 coal is of good quality and the bed was ısily handled. It is soft and friable, and in going through the rolls uch of it was reduced to a fine powder which gave trouble in the rubber and wash box. It yielded considerable tar and may be condered a good gas-producer coal.

COAL, WYOMING NO. 2, PRODUCER-GAS TEST NO. 16.

[Coal from mine of the Cambria Fuel Company, Cambria, Wyo.; tested December 16, 17, 1904.]

ıration of test ....hours..	30
ɔtal coal consumed in producer..............................pounds..	12,100
ɔisture in coal ....per cent..	9.44
·y coal consumed in producer...............................pounds..	10,958
·fuse from dry coal.......................................per cent..	22.9
tal refuse from coal......................................pounds..	2,509
tal combustible consumed in producer ....do....	8,449

Coal consumed, pounds per hour.

al consumed in producer	403.3
y coal consumed in producer	365.3
mbustible consumed in producer..............................	281.6
uivalent coal used by producer plant	459.8
uivalent dry coal used by producer plant.....................	416.5
uivalent combustible used by producer plant	321.1

British thermal units.

Per pound of coal as fired	9,650
Per pound of dry coal	10,656
Per pound of combustible	13.820
Per cubic foot of standard gas	151
From standard gas per pound dry coal burned in producer	6,168
From standard gas per hour per brake horsepower	9,516

Gas produced (cubic feet reduced to standard).

Total	447,700
Per hour	14,923
Per pound coal consumed in producer	37
Per pound dry coal consumed in producer	40.9
Per pound combustible consumed in producer	53
Per pound equivalent coal used by producer plant	32.5
Per pound equivalent dry coal used by producer plant	35.8
Per pound equivalent combustible used by producer plant	46.5

Horsepower developed.

Average electrical horsepower available for outside purposes	184.8
Average electrical horsepower developed at switch board	201.2
Average brake horsepower† available for outside purposes	217.4
Average brake horsepower† developed at engine	236.8

Coal consumed in producer, pounds per horsepower per hour.

	Coal as fired.	Dry coal.	Combus-tible.
Per electrical horsepower available for outside purposes	2.18	1.98	1.5[illegible]
Per electrical horsepower developed at switch board	2.00	1.82	1.4[illegible]
Per brake horsepower† available for outside purposes	1.86	1.68	1.3[illegible]
Per brake horsepower† developed at engine	1.70	1.54	1.1[illegible]
Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	2.49	2.25	1.7[illegible]
Equivalent pounds used by producer plant per electrical horsepower developed at switch board	2.28	2.07	1.6[illegible]
Equivalent pounds used by producer plant per brake horsepower† available for outside purposes	2.11	1.92	1.4[illegible]
Equivalent pounds used by producer plant per brake horsepower† developed at engine	1.94	1.76	1.[illegible]

Average composition of coal and gas.

COAL.	Per cent.
Moisture	9.44
Volatile matter	35.02
Fixed carbon	34.82
Ash	20.72
Sulphur	3.91

GAS BY VOLUME.	Per ce[illegible]
Carbon dioxide	10.[illegible]
Oxygen	.[illegible]
Carbon monoxide	15.[illegible]
Hydrogen	10.[illegible]
Methane	5.[illegible]
Nitrogen	57.[illegible]
	100.[illegible]

† Based on an assumed efficiency of 85 per cent for generator and belt.

Brief summary of producer-gas tests of eighteen bituminous coals and lignites.

Duration in hours.	Name of sample.	COAL PER HOUR, POUNDS. Consumed in producer. Coal as fired.	Consumed in producer. Dry coal.	Consumed in producer. Combustible.	Equivalent used by producer plant. Coal as fired.	Equivalent used by producer plant. Dry coal.	Equivalent used by producer plant. Combustible.	BRITISH THERMAL UNITS. Per pound. Coal as fired.	Per pound. Dry coal.	Per pound. Combustible.	Per cubic foot of standard gas.	From standard gas per pound of dry coal consumed in producer.	From standard gas per hour per brake horsepower.
3	4	5	6	7	8	9	10	11	12	13	14	15	16
43.00	Alabama No. 2	310.5	299.0	280.0	341.4	328.7	306.8	12,865	13,365	14,820	149.2	9,000	11,[illegible]20
30.00	Colorado No. 1	304.4	290.7	269.3	428.4	341.7	316.6	9,767	12,246	13,210	149.0	7,860	9,[illegible]00
30.00	Illinois No. 3	350.0	323.3	289.3	386.0	356.7	319.2	12,046	13,041	14,560	154.8	8,330	11,[illegible]00
30.00	Illinois No. 4	350.0	306.3	274.1	398.2	348.5	311.9	11,237	12,834	14,344	151.5	8,840	11,[illegible]20
29.67	Indiana No. 1	394.5	349.3	309.5	434.6	384.8	341.0	11,534	13,037	14,720	153.7	7,730	11,[illegible]80
7.00	Indiana No. 2	300.0	274.0	244.8	338.0	312.0	278.8	11,822	12,953	14,500	159.3	10,140	11,[illegible]50
31.00	Indian Territory No. 1	361.0	344.0	312.0	392.7	374.0	339.3	12,787	13,455	14,800	159.2	8,620	12,[illegible]50
30.00	Kentucky No. 3	370.0	343.3	310.0	410.8	381.2	344.2	12,283	13,226	14,650	155.9	8,610	12,[illegible]40
4.33	Missouri No. 2	346.5	306.0	255.0	384.5	339.6	283.0	10,505	11,882	14,280	140.0	8,820	11,[illegible]60
22.33	Montana No. 1	456.5	404.5	355.8	506.8	449.1	395.0	10,575	11,934	13,580	160.8	6,580	11,[illegible]40
30.00	North Dakota No. 2	460.0	278.0	249.0	510.0	308.0	275.8	6,802	11,255	12,600	188.5	7,830	13,[illegible]70
21.67	Texas No. 1	590.0	393.0	332.0	660.0	439.5	371.3	7,267	10,928	12,945	169.7	7,260	12,[illegible]30
19.33	Texas No. 2	468.0	310.3	276.2	519.5	344.4	306.6	7,348	11,086	12,450	156.2	8,060	10,[illegible]70
24.00	West Virginia No. 1	287.5	283.0	265.5	320.6	315.6	296.1	14,166	14,396	15,350	144.4	9,260	11,[illegible]30
9.00	West Virginia No. 4	233.0	229.0	208.0	262.8	258.2	234.5	13,918	14,202	15,600	143.2	11,610	11,[illegible]20
6.33	West Virginia No. 9	300.0	292.0	274.9	328.9	320.1	301.4	14,195	14,580	15,500	151.0	8,150	10,[illegible]60
30.00	West Virginia No. 12	270.0	266.1	248.7	304.9	300.5	280.9	14,614	14,825	15,860	142.5	10,150	11,[illegible]00
30.00	Wyoming No. 2	403.3	365.3	281.6	459.8	416.5	321.1	9,650	10,656	13,820	151.0	6,168	9,[illegible]16

Name of sample.	CUBIC FEET STANDARD GAS PRODUCED (62° F., 14.7 pounds pressure.) Per hour.	Per pound consumed in producer. Coal as fired.	Per pound consumed in producer. Dry coal.	Per pound consumed in producer. Combustible.	Per pound equivalent used by producer plant. Coal as fired.	Per pound equivalent used by producer plant. Dry coal.	Per pound equivalent used by producer plant. Combustible.	ECONOMIC RESULTS. (Pounds of coal consumed in producer per horsepower per hour.) Per electrical horsepower available for outside purposes. Coal as fired.	Dry coal.	Combustible.	Per electrical horsepower developed at switch board. Coal as fired.	Dry coal.	Combustible.	Per brake horsepower available for outside purposes. Coal as fired.	Dry coal.	Combustible.	Per brake horsepower developed at engine. Coal as fired.	Dry coal.	Combustible.
4	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Alabama No. 2	18,050	58.1	60.4	64.5	52.9	55.0	58.9	1.61	1.55	1.45	1.55	1.49	1.40	1.37	1.32	1.23	1.32	1.27	1.19
Colorado No. 1	15,343	42.1	52.8	57.0	35.8	44.9	48.5	1.95	1.56	1.45	1.82	1.45	1.35	1.66	1.32	1.23	1.55	1.23	1.14
Illinois No. 3	17,412	49.8	53.9	60.2	45.1	48.8	54.5	1.82	1.68	1.50	1.75	1.62	1.45	1.54	1.43	1.28	1.49	1.38	1.23
Illinois No. 4	17,881	51.1	58.4	65.3	44.9	51.4	57.4	1.85	1.62	1.45	1.76	1.55	1.38	1.57	1.37	1.23	1.50	1.31	1.17
Indiana No. 1	17,500	44.5	50.3	56.7	40.4	45.6	51.5	2.10	1.86	1.64	1.97	1.75	1.55	1.78	1.58	1.40	1.68	1.49	1.32
Indiana No. 2	17,450	58.2	63.6	71.3	51.6	55.9	62.6	1.57	1.43	1.28	1.49	1.36	1.22	1.33	1.22	1.09	1.27	1.16	1.03
Indian Territory No. 1	18,613	51.6	54.1	59.4	47.4	49.9	54.6	1.84	1.76	1.59	1.77	1.69	1.53	1.57	1.50	1.36	1.50	1.43	1.30
Kentucky No. 3	18,943	51.2	55.1	61.1	46.2	49.7	55.0	1.95	1.81	1.63	1.85	1.71	1.55	1.66	1.54	1.39	1.57	1.46	1.32
Missouri No. 2	19,300	55.7	63.0	75.7	50.2	56.8	68.2	1.87	1.65	1.37	1.74	1.54	1.28	1.59	1.40	1.17	1.48	1.31	1.09
Montana No. 1	16,540	36.2	40.9	46.5	32.6	36.8	41.9	2.39	2.12	1.86	2.29	2.03	1.78	2.03	1.80	1.58	1.95	1.72	1.52
North Dakota No. 2	11,550	25.2	41.5	46.4	22.7	37.5	41.9	3.67	2.22	1.99	3.42	2.07	1.86	3.13	1.89	1.69	2.91	1.76	1.58
Texas No. 1	16,800	28.4	42.7	50.6	25.5	38.2	45.3	3.16	2.10	1.78	2.98	1.99	1.68	2.68	1.79	1.51	2.54	1.69	1.43
Texas No. 2	16,000	34.2	51.6	57.9	30.8	46.4	52.2	2.47	1.64	1.46	2.33	1.54	1.37	2.10	1.39	1.24	1.98	1.31	1.17
West Virginia No. 1	18,150	63.2	64.1	68.4	56.6	57.5	61.3	1.51	1.49	1.40	1.43	1.41	1.33	1.29	1.27	1.19	1.22	1.20	1.13
West Virginia No. 4	18,560	79.6	81.2	89.2	70.6	71.9	79.2	1.23	1.21	1.10	1.17	1.15	1.04	1.05	1.03	.94	.99	.98	.89
West Virginia No. 9	15,770	52.0	54.0	57.4	48.0	49.3	52.3	1.60	1.56	1.47	1.49	1.46	1.37	1.36	1.33	1.25	1.27	1.24	1.16
West Virginia No. 12	18,957	70.2	71.2	76.2	62.1	63.2	67.5	1.41	1.39	1.30	1.35	1.33	1.24	1.20	1.18	1.11	1.15	1.13	1.06
Wyoming No. 2	14,923	37.0	40.9	53.0	32.5	35.8	46.5	2.18	1.98	1.52	2.00	1.82	1.40	1.86	1.68	1.30	1.70	1.54	1.19

Name of sample.	ECONOMIC RESULTS. (Equivalent pounds of coal used by producer plant per horsepower per hour.) Per electrical horsepower available for outside purposes. Coal as fired.	Dry coal.	Combustible.	Per electrical horsepower developed at switch board. Coal as fired.	Dry coal.	Combustible.	Per brake horsepower available for outside purposes. Coal as fired.	Dry coal.	Combustible.	Per brake horsepower developed at engine. Coal as fired.	Dry coal.	Combustible.	AVERAGE COMPOSITION OF GAS BY VOLUME, PER CENT. Carbonic acid, CO_2.	Oxygen, O_2.	Carbonic oxide, CO.	Hydrogen, H_2.	Marsh gas, CH_4.	Nitrogen, N_2.	Name of sample.
4	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	4
Alabama No. 2	1.77	1.71	1.59	1.71	1.64	1.53	1.51	1.45	1.35	1.45	1.40	1.30	8.16	.10	16.65	7.20	5.64	62.24	Alabama No. 2
Colorado No. 1	2.30	1.83	1.70	2.14	1.71	1.58	1.95	1.56	1.44	1.82	1.45	1.34	10.11	.55	17.38	11.05	5.00	55.90	Colorado No. 1
Illinois No. 3	2.01	1.85	1.66	1.93	1.79	1.60	1.70	1.58	1.41	1.64	1.52	1.36	10.53	.15	15.31	8.35	4.46	61.19	Illinois No. 3
Illinois No. 4	2.11	1.84	1.65	2.01	1.76	1.57	1.79	1.56	1.40	1.71	1.50	1.34	9.72	.12	15.12	9.98	6.00	59.06	Illinois No. 4
Indiana No. 1	2.31	2.04	1.81	2.17	1.93	1.71	1.96	1.74	1.54	1.85	1.64	1.45	9.89	.25	14.10	9.56	6.08	60.13	Indiana No. 1
Indiana No. 2	1.77	1.63	1.46	1.68	1.55	1.39	1.52	1.39	1.24	1.43	1.32	1.18	11.80	.07	11.46	10.60	6.10	59.97	Indiana No. 2
Indian Territory No. 1	2.00	1.91	1.73	1.92	1.83	1.66	1.71	1.62	1.47	1.64	1.56	1.41	8.25	.11	19.39	7.69	4.92	59.65	Indian Territory No. 1
Kentucky No. 3	2.16	2.01	1.81	2.05	1.91	1.72	1.84	1.71	1.54	1.75	1.62	1.40	10.87	.20	12.45	10.92	6.52	58.95	Kentucky No. 3
Missouri No. 2	2.07	1.83	1.52	1.94	1.71	1.43	1.76	1.55	1.30	1.65	1.45	1.21	12.07	.20	10.53	7.63	6.33	63.23	Missouri No. 2
Montana No. 1	2.65	2.35	2.07	2.54	2.25	1.98	2.26	2.00	1.76	2.16	1.91	1.68	9.04	.36	18.67	8.00	4.84	59.10	Montana No. 1
North Dakota No. 2	4.07	2.46	2.20	3.80	2.29	2.05	3.47	2.09	1.88	3.23	1.95	1.74	8.69	.23	20.90	14.33	4.85	51.02	North Dakota No. 2
Texas No. 1	3.53	2.35	1.99	3.34	2.22	1.88	3.00	2.20	1.69	2.83	1.99	1.60	11.10	.22	14.43	10.54	7.48	56.22	Texas No. 1
Texas No. 2	2.74	1.82	1.62	2.58	1.71	1.52	2.33	1.55	1.38	2.20	1.46	1.30	9.60	.20	18.22	9.63	4.81	57.53	Texas No. 2
West Virginia No. 1	1.69	1.66	1.56	1.60	1.57	1.48	1.43	1.41	1.33	1.36	1.34	1.26	10.50	.10	14.34	2.81	5.56	66.69	West Virginia No. 1
West Virginia No. 4	1.39	1.36	1.24	1.32	1.29	1.17	1.18	1.16	1.05	1.12	1.10	1.00	10.16	.24	15.82	11.16	3.74	58.88	West Virginia No. 4
West Virginia No. 9	1.76	1.71	1.61	1.64	1.59	1.50	1.49	1.46	1.37	1.39	1.35	1.27	10.40	.20	13.70	9.55	6.60	59.55	West Virginia No. 9
West Virginia No. 12	1.59	1.57	1.47	1.53	1.50	1.40	1.35	1.34	1.25	1.30	1.28	1.20	10.34	.12	14.21	12.98	4.61	57.75	West Virginia No. 12
Wyoming No. 2	2.49	2.25	1.74	2.28	2.07	1.60	2.11	1.92	1.48	1.94	1.76	1.36	10.21	.59	15.46	10.79	5.52	57.43	Wyoming No. 2

a Gas producer hopper leaked during these tests.

05 (Face page 117.)

The Wyoming No. 2 is a bituminous coal. It burned without any linkering, leaving a large amount of white ash similar to that obtained rom wood. The gas was not uniform in quality, on account of the diffiulty experienced in keeping the bed in good condition. An unusually rge amount of yellow tar was taken from the gas.

SUMMARY OF RESULTS.

The table given herewith shows in a condensed form the results btained in the producer-gas tests.

COMPARISON OF RESULTS OBTAINED FROM STEAM AND PRODUCER-GAS TESTS.

By Robert H. Fernald and L. P. Breckenridge.

STEAM PLANT.

The accompanying table, showing the comparative results of burning the various coals under the boiler and in the gas producer, is of much interest and value.

It is to be recollected that the steam generated by the boiler was used in a simple noncondensing engine of the Corliss type, whose "water rate" was 26.3 pounds of steam per hour per horsepower developed; that this engine was belted to the electric generator, and that the mechanical efficiency of this combination of engine and generator was 81 per cent.

With these figures available it will be an easy matter to calculate the number of pounds of coal which would have been required to produce an electrical horsepower provided a more economical type of steam engine had been used, or if the electrical generator had been directly connected to the engine, with the resulting advantage of a higher mechanical efficiency.

If, for example, the steam generated had been used by a steam engine capable of generating 1 horsepower with 18 pounds of steam per hour, and if the engine and generator had been direct connected, giving as high a mechanical efficiency as 90 per cent, then the "Total dry coal per electrical horsepower per hour" would have been reduced from 4.3 pounds, as given in column 13, to very nearly 3 pounds.

While these figures are frequently and easily attained by steam engines operating in large units, it will be conceded that in plants of from 200 to 250 horsepower they are but seldom reached.

It should be mentioned that the labor required would be the same for the operation of either the boiler plant or the gas-producer plant of the capacity under tests. In either plant two men would be sufficient.

Comparative summary of the leading results of the coal tests made under the boiler and in the gas producer.

Name of sample.	Duration of trial.		Total dry coal consumed per hour.[a]		Dry coal burned per square foot of grate surface per hour.		Water evaporated from and at 212° F. per pound of dry coal.	B. T. U. per pound of dry coal used.		Electrical horse-power delivered to switch board.		Total dry coal per electrical horse-power per hour.[a]	
	Steam plant.	Gas-producer plant.	Steam plant.	Gas-producer plant.	Steam plant.	Gas-producer plant.[b]	Steam plant.	Steam plant.	Gas-producer plant.	Steam plant.	Gas-producer plant.	Steam plant.	Gas-producer plant.
	Hours.	*Hours.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*					*Pounds.*	*Pounds.*
Alabama No. 2	10.02	43.00	874	328.7	21.54	7.78	8.55	12,555	13,365	213.7	200.6	**4.08**	**1.64**
Colorado No. 1	9.97	30.00	722	341.7	17.80	7.56	7.21	12,577	12,245	149.1	200.2	**4.84**	**1.71**
Illinois No. 3	10.13	30.00	861	356.7	21.23	8.41	8.04	12,857	13,041	198.1	199.6	**4.34**	[c] **1.79**
Illinois No. 4	10.02	30.00	938	348.5	23.13	7.96	7.27	12,459	12,834	195.4	198.4	**4.80**	[c] **1.76**
Indiana No. 1	9.93	29.67	908	384.3	22.39	9.08	8.45	13,377	13,037	220.0	199.9	**4.13**	[c] **1.93**
Indiana No. 2	10.13	7.00	832	312.0	20.51	7.13	8.02	12,452	12,953	191.0	201.0	**4.35**	[c] **1.55**
Indian Territory No. 1	9.75	31.00	778	374.0	19.17	8.95	8.64	12,834	13,455	192.3	204.0	**4.04**	**1.83**
Kentucky No. 3	10.07	30.00	882	381.2	21.75	8.92	8.27	13,036	13,226	208.9	200.5	**4.22**	[c] **1.91**
Missouri No. 2	9.98	4.33	1,014	339.6	25.00	7.96	7.08	11,500	11,882	205.6	198.6	**4.93**	[c] **1.71**
West Virginia No. 1	9.98	24.00	768	315.6	18.94	7.36	8.95	14,198	14,396	196.7	200.4	**3.90**	**1.57**
West Virginia No. 4	10.00	9.00	770	258.2	18.98	5.96	9.65	14,002	14,202	212.5	199.7	**3.62**	**1.29**
West Virginia No. 9	10.00	6.33	721	320.1	17.78	7.60	10.09	14,616	14,580	208.2	201.0	**3.46**	**1.59**
West Virginia No. 12	10.13	30.00	719	300.5	17.68	6.92	9.90	15,170	14,825	203.6	199.8	**3.53**	[c] **1.50**
Wyoming No. 2	9.95	30.00	1,075	416.5	26.51	9.50	5.92	10,897	10,656	182.0	201.2	**5.90**	**2.07**

[a] In gas-producer plant this includes the coal consumed in the producer and the coal equivalent of the steam used in operating the producer.
[b] Coal actually consumed in producer only.
[c] Gas-producer hopper leaked during these tests.

GAS-PRODUCER PLANT.

In considering the possible increase in efficiency of the boiler tests with a compound engine substituted for the simple engine used, the fact should not be overlooked that a corresponding increase in the efficiency of the gas-producer tests may be brought about under the most favorable conditions. The gas engine is passing through a transitional period. In the larger sizes the vertical single-acting engine is being replaced by the horizontal double-acting. Other changes and improvements are constantly being made which tend to do for the gas engine what compounding and tripling the expansions have already done for the steam engine.

The gas engine used in the trials recorded is a vertical three-cylinder, single-acting engine with no means of changing the ignition while the engine is running. A brief consideration of these points will lead at once to the conclusion that the gas engine and steam engine used in these tests compare very favorably, and that any increase in efficiency in the boiler tests that might result from using a compound engine can be offset by the introduction of the more modern type of gas engine.

COKING TESTS.

By Fred. W. Stammler.

INTRODUCTION.

The tests of the coking qualities of the coals received at the testing lant were made in a battery of three bee-hive ovens. The ovens are f standard size and shape, 12 feet in diameter and 7 feet high, and ey were built from plans furnished by Mr. John Fulton, the well-nown expert on coke making, of Johnstown, Pa. The writer was sisted in making the coking tests by Mr. B. B. Boyd, of Uniontown, a. The analyses given in the table at the end of this report, of coals at were charged in the coke ovens, and of the resulting cokes, were l made at the chemical laboratory of the testing plant under the rection of Prof. N. W. Lord, of Columbus, Ohio.

The ovens were fired on September 10, and were kept in blast until ecember 16. During this time 61 tests were made, embracing 44 fferent coals, coming from 11 States. Thirty-two tests were made 29 different samples of raw coal, and 27 tests were made on 24 mples of washed coal. Two tests were made on briquettes of non-king coal, having an additional amount of volatile matter used as a nding material. All of the coal charged into the ovens was first ssed through rolls reducing it to 1½ inches or smaller.

RESULTS OF TESTS.

The results of the coking tests have been arranged alphabetically by ates, the general number adopted for all tests being given for ready entification, and are briefly summarized as follows:

Alabama No. 1.—Lump and nut coal from mine No. 8, Ivy Coal d Iron Company, Horse Creek, Ala.

Two charges were made of this coal, the first being unwashed and the cond washed. The first charge of unwashed coal consisted of 8,000 unds. Although the coking process was continued for 88 hours, the ke was very light, of a spongy structure, and high in ash. Washing duced the percentage of impurities but slightly, though it is believed

that with more thorough washing a coke of good quality might be obtained. The charge of washed coal weighed 9,800 pounds, was burned for 65 hours, and produced 5,731 pounds of coke,[a] a percentage yield of 58.5. This coke was also soft and high in ash.

Alabama No. 2.—Lump, nut, and pea coal from mine No. 5, Galloway Coal Company, Carbon Hill, Ala.

The coal used in this test was unwashed, the charge weighing 8,000 pounds. It coked imperfectly in small pieces, which were very soft and which were mixed with charred coal and ash. The coal is high in ash (13.04 per cent), but if properly washed may yield a coke of fair grade.

Arkansas No. 1.—Lump and nut coal from mine No. 3, Central Coal and Coke Company, Huntington, Ark.

The charge consisted of 8,075 pounds of unwashed coal, which showed no tendency to coke and burned to ash. The volatile constituents are too low to make coke in the beehive oven. If properly washed this coal may make coke in a retort oven. It is high in ash (13.01 per cent) and also somewhat high in sulphur.

Arkansas No. 2.—Lump coal from mine No. 12, Central Coal and Coke Company, Bonanza, Ark. Same result as obtained from Arkansas No. 1.

Arkansas No. 3.—Lump and slack coal from mine No. 18, Western Coal and Mining Company, Jenny Lind, Ark. This was an experimental charge of a small amount of briquettes made from unwashed coal and placed in an oven with a coking coal. The briquettes contained 6 per cent of hard pitch and they produced a dense coke high in ash.

Arkansas No. 6.—Slack coal from mine No. 18, Western Coal and Mining Company, Jenny Lind, Ark.

The behavior of these two coals in the ovens was practically the same as that of Arkansas No. 1, except that No. 6 was washed and the percentage of ash shows a noticeable reduction.

The charge for a second test consisted of equal parts of unwashed coal crushed and mixed with 8 per cent of hard pitch, and the same material made into briquettes on the English machine. The addition of the pitch, by increasing the volatile matter, caused the coal to fuse and produced coke. The coke, however, was very dark and had large cells. The test is interesting, since it shows that a naturally noncoking coal may be made to coke by an addition of pitch. The charged weighed 8,000 pounds, was burned 42 hours, and yielded 4,056 pounds of coke and 539 pounds of breeze and ash.

Illinois No. 1.—Lump and nut coal from mine No. 1, Western Anthracite Coal and Coke Company, O'Fallon, Ill.

[a] Exclusive of 352 pounds of breeze and ash.

This test was made on a charge of 9,000 pounds of unwashed coal, which was burned for 43 hours. It produced some small pieces of oke, mixed with charred coal and ash. The coal is too high in ash 15.95 per cent) and sulphur (4.14 per cent) to produce a coke fit for last-furnace use.

Illinois No. 2.—Slack coal from the same mine as No. 1.

This coal was washed (p. 62) before charging into the ovens, reducng the ash to 9.19 per cent. The amount of coal charged was 9,000 ounds, which after burning 64 hours yielded 3,389 pounds of mixed ard and soft coke and 352 pounds of breeze and ash. The coke conained 20.18 per cent of ash and 2.75 per cent of sulphur.

Illinois No. 3.—Run-of-mine coal from mine No. 3, Southern Illinois Coal Mining and Washing Company, near Marion, Ill.

Two charges were made of this coal, one unwashed, the other washed. The unwashed charge of 9,000 pounds was tested for 43 hours. The oal lay dead in the oven, burning on top, but did not coke. The nwashed coal contained 10.59 per cent ash. The washed charge carried 5.86 per cent ash, being a reduction of nearly 50 per cent (p. 66). This charge of washed coal consisted of 13,000 pounds and was burned 0 hours, yielding 6,378 pounds of coke, which was very brittle and which broke up in handling into fine-fingered pieces. The breeze and sh in this oven weighed 834 pounds.

Illinois No. 5.—Grade No. 5, washed slack from mine No. 1, Donk ros. Coal and Coke Company, Collinsville, Ill.

Three tests were made of this coal, as it was reported that it had een coked successfully in pits. All of the coal was washed before harging and each charge was burned for 42 hours. In the first test he coal was charged as it was received, but no coke was produced. n the second test the coal was rewashed through the New Century g (p. 67), but it was charged wet and the oven was chilled and the oal would not burn. In the last test the oven was heated by an extra harge of coal and the charge was made in a red-hot oven, but even ith this precaution the coal would not coke. In each instance the oal burned out on top, but otherwise lay dead in the oven and would ot coke under existing conditions. All of the Illinois coals are too gh in sulphur to make good blast-furnace coke.

Indiana No. 1.—Run-of-mine coal from Mildred mine, J. Woolley oal Company, Mildred, Ind.

This coal was crushed and washed (p. 64). The charge consisted 8,000 pounds and was burned for 40 hours. It produced 3,473 ounds of fair coke of medium weight, bright gray, but brittle and ther high in sulphur. The breeze and ash amounted to 368 pounds.

Indian Territory No. 1.—Lump and slack coal from mine No. 1, Whitehead Coal and Mining Company, Henryetta, Ind. T.

This test was made on 8,095 pounds of unwashed coal. It lasted 4 hours, and nothing but ash was left in the oven. The coal showed n tendency to coke.

Indian Territory No. 2.—Run-of-mine coal from mine No. 8, o Rock Island Coal Company, Hartshorne, Ind. T.

Two tests were made on this coal, washed and unwashed. Bot charges weighed 9,000 pounds. The unwashed charge was burned fo 66 hours, and yielded 5,725 pounds of coke and 580 pounds of breez and ash. The coke was very soft, shattered and brittle, and somewha high in sulphur. The washed charge contained one-third less ash tha the unwashed (p. 67). It was burned for 65 hours, producing a cok which was hard and which had a fairly good ring. It showed consid erable improvement in appearance over the coke made from unwashe coal, but the sulphur content was not materially reduced.

Indian Territory No. 3.—Run-of-mine coal from mine No. 1, D Edwards & Sons, Edwards, Ind. T.

Two tests were made on this coal, the first being on 12,000 pound of unwashed coal, burned 65 hours, and the second on 14,000 pound washed coal, burned 66 hours. The washed coal, instead of showin a reduced percentage of sulphur, showed a gain (p. 68). Neithe charge yielded coke. The ovens when drawn contained small pieces c charred coal and ash.

Indian Territory No. 5.—Slack and pea coal from mine No. 7, Wes ern Coal and Mining Company, Lehigh, Ind. T.

This test was made on 10,000 pounds of washed coal and was co tinued for 65 hours (p. 68). It produced some small pieces of cok fritted together, light and soft. The general conclusion regarding th Territory coals tested is that when properly washed they will produ coke, but not of a character suited for iron smelting, as the sulph is too intimately combined or mixed with the coal to be removed b washing.

Iowa No. 1.—Lump and fine coal from mine No. 2, Anchor Co Company, Laddsdale, Iowa.

In this test, as in all those on Iowa coals, the charge was of wash coal (p. 68). The charge weighed 9,500 pounds, and after burning hours yielded 4,828 pounds of coke and 572 pounds of breeze and as The coke was brittle, with cracks lengthwise and crosswise through It was also high in sulphur and ash.

Iowa No. 2.—Run-of-mine coal from mine No. 5, Mammoth Ve Coal Company, Hamilton, Iowa.

The charge in this test consisted of 10,000 pounds of washed co which was burned for 64 hours (p. 69). The coke (3,866 pounds w 1,153 pounds of breeze and ash) was all in small pieces sintered togetl and with no bond.

Iowa No. 3.—Lump coal from mine No. 4, Gibson Coal Mining ompany, Altoona, Iowa.

The charge in this test consisted of 8,000 pounds of washed (p. 69) oal, which was burned for 43 hours. It yielded 3,336 pounds of fine-ngered brittle coke that was high in sulphur and ash, and 585 pounds f breeze and ash.

Iowa No. 4.—Lump coal from mine No. 3, Centerville Block Coal ompany, Centerville, Iowa.

The coke produced in this test was of the same general character as hat obtained from Iowa No. 3, except that it was not quite so high in ither sulphur or ash. The charge consisted of 8,000 pounds of ashed (p. 69) coal, which was burned for 40 hours, producing 3,722 ounds of coke and 426 pounds of breeze and ash.

Iowa No. 5.—Run-of-mine coal from Inland mine No. 1, Inland uel Company, Chariton, Iowa.

The result of this test, made on 9,000 pounds of washed (p. 70) coal, nd burned 66 hours, was a mixture of unburned coal, charred coke, nd ash.

All of the Iowa coals tested are too high in sulphur to produce last-furnace coke, and as the sulphur occurs largely as gypsum it n not be removed by washing. The ash is also high in relation to e fixed carbon.

Kansas No. 1.—Run-of-mine coal from mine No. 10, Western Coal d Mining Company, Fleming, Kans.

In making this test a charge of 11,300 pounds was made, and this as burned for 120 hours. At the end of the period the charge was und to be sintered on top, while under this sintering was a thin layer light coke, with the remainder of the coal in the oven uncoked or rned.

Kansas No. 2.—Lump, nut, and slack coal from mine No. 11, West-n Coal and Mining Company, Yale, Kans.

The behavior of this coal in the oven was similar to that of Kansas o. 1, showing no tendency to coke, although the charge of 9,125 unds was burned for 159 hours.

Kansas No. 3.—Run-of-mine coal from mine No. 9, Southern Coal d Mercantile Company, Scammon, Kans.

This charge consisted of 7,100 pounds of unwashed coal, which was rned for 96 hours. It coked for about 12 inches from the top, ile the remainder was simply charred coal and ash.

Kansas No. 4.—Lump coal from Atchison Coal Mining Company, chison, Kans.

This coal showed more of a tendency to coke than any of the other als from Kansas. The charge, consisting of 10,000 pounds, was rned for 67 hours. It yielded 5,213 pounds of hard but brittle coke d 432 pounds of breeze and ash. The coke is, however, too high in

sulphur (6.15 per cent) for use in an iron furnace, but it may be used in lead and zinc smelters, for which purpose a high percentage of sulphur is not detrimental.

Kentucky No. 1.—Run-of-mine coal from Straight Creek mine No. 2 of the National Coal and Iron Company, Straight Creek, Kentucky.

This test was made on 10,000 pounds of unwashed coal burned for 66 hours. It produced 5,441 pounds of hard coke, which was fine-fingered and easily broken into small pieces. The breeze and ash weighed 355 pounds.

Kentucky No. 3.—Run-of-mine coal from Barnsley mine of St. Bernard Mining Company, Earlington, Ky.

In this test the charge consisted of 10,000 pounds of washed coal (p. 70), burned for 66 hours. It produced a coke of fair quality, of good color and ring, but somewhat high in sulphur. It produced 5,433 pounds of coke and 426 pounds of breeze and ash.

Kentucky No. 4.—Run-of-mine coal from Wheatcroft Coal and Mining Company, Wheatcroft, Ky.

This test was also made on 10,000 pounds washed coal (p. 70), which was burned for 66 hours, and yielded 5,558 pounds of coke and 313 pounds of breeze and ash. The coke was of good color and ring, but like Kentucky No. 4, was too high in sulphur for blast-furnace use.

Missouri No. 2.—Run-of-mine coal from mine No. 8 of the Northwestern Coal and Mining Company, Bevier, Mo.

This charge consisted of 12,000 pounds washed coal (p. 70), which was coked for 87 hours. It yielded 5,040 pounds of long-fingered brittle coke, having large pieces of slate mixed through it. The breeze and ash amounted to 580 pounds. The coke is high in both sulphur and ash.

Missouri No. 3.—Slack coal from Mendota Coal and Mining Company, Mendota, Mo.

This coal showed no tendency whatsoever to coke, although it was washed (p. 65) and burned for 42 hours.

Missouri No. 4.—Run-of-mine coal from Morgan County Coal Company, near Barnett, Mo.

This coal produced a coke of fair grade, of a gray color, and of good metallic ring. The charge was 11,000 pounds of unwashed coal and yielded 4,905 pounds of coke and 128 pounds of breeze and ash. The coke, however, is too high in sulphur for blast-furnace use, but is believed that the quality of this coke could be improved by washing the coal before charging into the ovens.

West Virginia No. 1.—Run-of-mine coal, Virginia and Pittsburg Coal Company, Kingmount, W. Va.

This test was made on 9,000 pounds of unwashed coal. The charge was burned for 64 hours and yielded 5,572 pounds of coke and 2

ounds of breeze and ash. The coke was of good quality, but some-hat brittle.

West Virginia No. 2.—Run-of-mine coal from Pitcairn mine of the itcairn Coal Company, Clarksburg, W. Va.

Two tests were made of this coal, unwashed and washed. The first harge was 9,000 pounds of unwashed coal, producing 5,235 pounds of ray coke, somewhat brittle and high in sulphur and ash. The washed oal (p. 71), of which 13,000 pounds was charged, showed an improve-ent in the coke, though the sulphur was still too high for blast-urnace use. The yield from the second charge was 7,808 pounds, or) per cent, as compared with 58.2 per cent from the unwashed coal.

West Virginia No. 3.—Run-of-mine coal from West Virginia Coal ompany, Richard, W. Va.

Two tests, one of unwashed and one of washed coal, were made on is sample. The charge of unwashed coal weighed 9,000 pounds and as coked 41 hours. It yielded 5,929 pounds of coke of gray color, rittle and somewhat high in ash, and 364 pounds of breeze and ash. he washed charge (p. 71) weighed 14,000 pounds, was coked for 66 ours, and yielded 9,070 pounds of coke of the same character as noted bove and 535 pounds of ash and breeze. The quality of the coke was ot improved by washing, except by a small reduction in the amount f ash.

The first test of 41 hours' duration gave a yield of 65.9 per cent, the cond test of 66 hours gave a yield of 64.8 per cent.

West Virginia No. 4.—Run-of-mine coal from West Virginia Coal ompany, Bretz, W. Va.

This coal was tested washed and unwashed. The unwashed charge ntained 12,000 pounds. It was burned for 65 hours and yielded 907 pounds, or 74.2 per cent, of coke, and 428 pounds of breeze and h. The charge of washed coal (p. 71) weighed 9,000 pounds. It was ked for 42 hours and yielded 6,367 pounds, or 70.7 per cent, of coke, d 374 pounds of breeze and ash. The coke obtained was of good lor, but was somewhat impaired by cross fractures. No improve-nt was noticed as a result of washing.

West Virginia No. 5.—Lump and nut coal from Davis Colliery mpany, Coalton, W. Va.

Three coking tests were made on this shipment, one of unwashed d one of washed run-of-mine, crushed before coking to 1½ inches diameter, and one of pulverized coal which was washed in the New ntury jig (p. 72). The first charge of unwashed coal, weighing 000 pounds, was burned for 64 hours and yielded 8,298 pounds, or 8 per cent, of coke, and 497 pounds of ash and breeze. The washed rge, weighing 13,000 pounds, was burned 66 hours. It yielded 63 pounds, or 55.1 per cent, of coke, and 461 pounds of ash and eeze. The pulverized coal, weighing 10,000 pounds, was burned 69

hours and yielded 4,256 pounds, or 42.56 per cent, of coke, and 229 pounds of ash and breeze. The results showed that the coal would make a good coke if the ash could be materially reduced. Washing in this case lowered the percentage of ash from 19.14 per cent in the first test to 14.81 per cent in the second and 15.98 per cent in the third. The results of these tests show that the washing of this coal for coking purposes is advisable.

West Virginia No. 6.—Run-of-mine coal from the New River Smokeless Coal Company, Rush Run, W. Va.

Three tests were made on this coal, which was unwashed. The first charge, consisting of 13,000 pounds, was burned for 90 hours, and yielded 8,303 pounds, or 63.9 per cent, of light-gray, soft coke. The second charge, which consisted of 9,000 pounds, was burned for 66 hours, and yielded 6,399 pounds, or 71.1 per cent, of coke, of somewhat better quality than the first, although still gray and light. The charge consisted of 8,000 pounds of pulverized coal. It was burned for 44 hours, and yielded 5,849 pounds, or 73.1 per cent, of coke, which was dense and tough, but light in weight and color, and of poor ring.

West Virginia No. 7.—Run-of-mine coal from the New River Smokeless Coal Company, Sun, W. Va.

This test was made on unwashed coal, the charge weighing 8,000 pounds. It produced 5,119 pounds, or 64 per cent, of coke of good size and quality, but rather dark in color.

West Virginia No. 8.—Run-of-mine coal from Gauley Mountain Coal Company, Ansted, W. Va.

This test was made on 11,000 pounds of unwashed coal, which was burned for 66 hours and yielded 7,124 pounds, or 64.7 per cent, of coke, and 589 pounds of ash and breeze. The coke was hard, of good color, although of somewhat irregular cell structure.

West Virginia No. 9.—Run-of-mine coal from Vulcan mine of the Mount Carbon Coal Company (Limited), Powellton, W. Va.

Two tests were made on this coal, the first being unwashed, the second washed. The unwashed charge weighed 10,000 pounds, and was burned 40 hours. It yielded 6,084 pounds, or 60.8 per cent, of coke and 314 pounds of breeze and ash. The coke was heavy and grayish in color. It was of good quality, though slightly brittle. The coke from the washed coal (p. 72) showed much improvement over that from the unwashed coal, and could be considered a high-grade coke. The charge of washed coal weighed 11,000 pounds, burned for 6 hours, and yielded 6,803 pounds, or 61.8 per cent, of coke, and only 7 pounds of ash and breeze.

West Virginia No. 10.—Lump and run-of-mine coal from Stuart M Buck, Mora, W. Va.

This test was made on 11,000 pounds of unwashed coal. It was burned for 68 hours and yielded 7,858 pounds, or 71.4 per cent,

ood, hard, heavy coke, slightly off color, and 429 pounds of ash and reeze.

West Virginia No. 11.—Run-of-mine coal from mines Nos. 1 and 2 f W. H. Coffman, Zenith, W. Va.

This was the only coal from West Virginia which did not coke in le ovens. The charge consisted of 11,000 pounds. It was burned or 67 hours, and when drawn consisted of ash mixed with raw, nburned coal.

West Virginia No. 12.—Run-of-mine coal from Big Sandy Coal and 'oke Company, Big Sandy, W. Va.

Two tests of this coal were made, the first being unwashed and the econd washed. The unwashed charge was 11,000 pounds. It was urned for 68 hours, and produced 7,082 pounds of coke, or 64.4 per ent, and 549 pounds of ash and breeze. The coke was of fair quality nd had a metallic ring. It was of good color, but showed cross fracures. The washed charge (p. 73) of the same coal weighed 8,000 ounds, and was burned for 44 hours, producing 5,050 pounds, or 63.1 er cent, of coke and 583 pounds of ash and breeze. The coke was of rge size and grayish color, but not particularly strong.

CUPOLA TESTS OF COKE.

In connection with the coking tests of the coals the cokes made in e beehive ovens were not only analyzed and tested by various labotory methods, but those which gave promise of value in foundry roducts were also tested in the cupolas of the model foundry connected ith the Louisiana Purchase Exposition.

The testing of these cokes for foundry purposes was done under the pervision of a committee appointed for this purpose by the American undrymen's Association, the committee consisting of Dr. Richard oldenke, secretary of the association; Mr. Herbert E. Field, of cIntosh, Hemphill & Co., Pittsburg, Pa., and Mr. W. J. Fogarty, the Magnetite Foundry Company, St. Louis, Mo. Two thousand unds of each such coke—one dozen samples in all—were reserved r these tests, and the cupola tests were made under the immediate pervision of Doctor Moldenke, during the month of November, using r this purpose two 36-inch small foundry cupolas, one of which was rnished by the Whiting Foundry Equipment Company, of Chicago, d the other by the J. S. McCormick Company, of Pittsburg.

The analyses of the cokes and the iron used in the tests have not yet en completed, however, and it is, therefore, thought best to delay publication of the results of these tests until the issuance of a later port, in which will be included the tests of other cokes to be made ring the next few months.

Coking tests.

Name of sample.	Coal.								
	Condition.	Chemical composition.					Amount charged in oven.	Coking time.
		Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.		
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Pounds.*	*Hours*
Alabama No. 1	Raw	2.65	30.79	52.68	13.88	0.76	8,000	88
Do	Washed	4.64	31.28	53.02	11.06	0.89	9,800	65
Alabama No. 2	Raw	3.77	32.60	50.59	13.04	1.43	8,000	64
Arkansas No. 1	do	2.31	18.10	66.58	13.01	1.13	8,075	114
Arkansas No. 2	do	2.31	17.41	69.73	10.55	1.58	8,150	118
Arkansas No. 6	Washed	18.29	12.95	62.54	6.22	1.22	9,000	95
Arkansas No. 3	Briquetted						Small box.	65
Arkansas No. 6	do	4.59	17.25	64.12	14.04	1.68	8,000	42
Illinois No. 1	Raw	10.46	36.11	37.48	15.95	4.14	9,000	43
Illinois No. 2	Washed	17.20	35.77	37.84	9.19	3.03	9,000	64
Illinois No. 3	Raw	8.25	30.22	50.94	10.59	1.45	9,000	43
Do	Washed	9.52	32.05	52.57	5.86	1.41	13,000	90
Illinois No. 5	do	17.86	31.65	32.93	17.56	3.25	8,000	42
Illinois No. 5	do	25.15	28.68	36.99	9.18	2.71	5,000	42
Illinois 5	Washed	14.60	30.76	36.48	18.16	3.44	9,000	42
Indiana No. 1	do	16.53	36.38	40.05	7.04	2.03	8,000	40
Indian Territory No. 1	Raw	10.29	31.46	44.39	13.86	1.34	8,095	40
Indian Territory No. 2	do	3.82	37.45	48.74	9.99	1.47	9,000	66
Do	Washed	4.45	38.18	51.04	6.33	1.43	9,000	65
Indian Territory No. 3	Raw	4.16	36.66	49.43	9.75	3.16	12,000	65
Do	Washed	5.93	38.05	48.53	7.49	3.20	14,000	66
Indian Territory No. 5	do	16.95	33.30	41.61	8.14	2.90	10,000	65
Iowa No. 1	do	12.84	35.91	41.00	10.25	4.61	9,500	46
Iowa No. 2	do	12.85	35.44	35.43	10.28	3.93	10,000	64
Iowa No. 3	do	16.83	39.27	35.87	8.03	4.55	8,000	43
Iowa No. 4	do	17.80	37.59	37.39	7.14	3.59	8,000	40
Iowa No. 5	do	19.25	31.07	41.75	7.93	2.28	9,000	66
Kansas No. 1	Raw	8.10	31.26	45.82	14.84	4.48	11,300	120
Kansas No. 2	do	3.96	30.46	45.54	20.04	5.59	9,125	159
Kansas No. 3	do	1.75	32.95	48.39	16.91	5.60	7,100	96
Kansas No. 4	do	6.63	36.99	43.45	12.93	7.19	10,000	67
Kentucky No. 1	do	2.71	37.22	56.17	3.90	1.23	10,000	66
Kentucky No. 3	Washed	10.51	37.33	44.76	7.40	2.51	10,000	66
Kentucky No. 4	do	6.18	39.07	48.70	6.05	2.74	10,000	66
Missouri No. 2	do	14.14	35.53	42.57	7.76	3.24	12,000	87
Missouri No. 3	do	24.15	33.10	35.51	7.24	2.74	9,000	42
Missouri No. 4	Raw	12.04	41.35	41.34	5.27	5.14	11,000	65
West Virginia No. 1	Raw	1.93	36.50	54.97	6.60	.88	9,000	64
West Virginia No. 2	do	1.73	39.20	50.85	8.22	3.38	9,000	50
Do	Washed	3.98	39.76	49.21	7.05	2.84	13,000	6
West Virginia No. 3	Raw	2.25	30.60	57.40	9.75	.99	9,000	4
Do	Washed	4.11	29.54	57.34	9.01	1.18	14,000	6
West Virginia No. 4	Raw	2.72	27.62	59.16	10.50	.86	12,000	6
Do	Washed	3.47	27.95	61.05	7.53	.74	9,000	4
West Virginia No. 5	Raw	2.43	28.30	58.55	10.73	.90	13,000	6
Do	Washed	4.84	28.12	56.76	10.28	.91	13,000	6
Do	Washed, fine	19.50	23.76	48.55	8.19	.79	10,000	6

Coking tests.

Coke.										Remarks.
Amount produced.	Breeze and ash.	Chemical composition.						Specific gravity.	Per cent produced.	
		Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.			
Lbs.	*Lbs.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*			
......	......	......	......	......	......	......	......	......	......	Light, spongy.
5,731	352	0.33	0.72	82.63	16.32	0.69	0.047	1.94	58.5	Improved by washing.
......	......	......	......	......	......	......	......	......	......	Charred coal and ash.
......	......	......	......	......	......	......	......	......	......	No coke produced.
......	......	......	......	......	......	......	......	......	......	Do.
......	......	......	......	......	......	......	......	......	......	Do.
......	......	1.05	2.80	72.73	23.42	1.52	......	......	......	Placed in oven with charge of coal.
4,056	539	4.06	2.77	76.63	16.54	1.43	.050	1.88	50.7	50 per cent briquettes and 50 per cent coal charged.
......	......	......	......	......	......	......	......	......	......	Small coke and ash.
3,389	352	1.57	2.83	75.42	20.18	2.75	.030	1.87	37.6	Hard and soft mixed.
......	......	......	......	......	......	......	......	......	......	No coke, burned on top.
6,378	834	0.11	.42	82.55	10.92	1.13	.019	1.84	49.1	Fingered, brittle.
......	......	......	......	......	......	......	......	......	......	No coke produced.
......	......	......	......	......	......	......	......	......	......	Do.
......	......	......	......	......	......	......	......	......	......	Do.
3,473	368	5.71	1.18	80.52	12.59	1.69	.016	1.86	43.4	Fair coke, brittle.
......	......	......	......	......	......	......	......	......	......	Burned to ash.
5,725	580	8.15	1.74	75.68	14.43	1.50	.050	1.88	63.6	Coke soft.
4,680	255	.96	2.59	85.33	11.12	1.75	.043	1.84	52.0	Coke hard.
......	......	......	......	......	......	......	......	......	......	Small coke and ash.
......	......	......	......	......	......	......	......	......	......	Not improved.
......	......	......	......	......	......	......	......	......	......	Small coke fritted.
4,828	572	10.53	1.65	70.39	17.45	3.89	.051	1.87	50.7	Very brittle.
3,866	1,153	......	......	......	......	......	......	......	38.7	Sintered.
3,336	585	5.73	1.87	75.49	16.91	4.57	.0183	1.88	41.7	Fine fingered.
3,722	426	13.05	2.32	73.10	11.53	2.97	.0123	1.82	46.5	Do.
......	......	......	......	......	......	......	......	......	......	Charred coke and ash.
......	......	......	......	......	......	......	......	......	......	No coke produced.
......	......	......	......	......	......	......	......	......	......	Do.
......	......	......	......	......	......	......	......	......	......	Coked 12 inches from top.
,213	432	.52	1.68	79.82	17.98	6.15	.0148	1.92	52.1	Hard and brittle.
,441	355	1.48	.83	92.34	5.35	.84	.034	1.83	54.4	Hard, fine fingered.
,433	426	.14	.56	86.31	12.99	2.16	.009	1.81	54.3	Fair coke.
,528	313	.52	.63	86.50	12.35	2.37	.015	1.84	55.3	Good color.
,040	580	3.45	1.80	80.27	14.48	2.79	.02	1.86	42.0	Long fingered.
......	......	......	......	......	......	......	......	......	......	No coke produced.
,905	128	2.51	1.11	85.57	10.81	4.60	.018	1.83	44.6	Fair coke.
,572	268	.40	1.95	87.47	10.18	.71	.029	1.84	61.9	Good coke.
,235	286	.42	.68	83.95	14.95	3.40	.023	1.94	58.2	Gray, brittle.
,808	302	.59	1.31	86.70	11.40	2.24	.017	1.89	60.1	Improved by washing.
,929	364	.22	.83	80.77	18.18	.93	.065	1.95	65.9	Gray coke.
,070	535	.38	.87	84.48	14.27	1.19	.079	1.94	64.8	Not improved by washing.
,907	428	.62	1.43	86.10	11.85	.82	.031	1.84	74.2	Good coke.
,367	374	.20	1.15	85.42	13.23	.69	.019	1.94	70.7	Not improved by washing.
,298	497	2.60	1.12	77.14	19.14	.77	.067	1.90	63.8	Good coke, too much ash.
,163	461	.42	.43	84.34	14.81	.83	.086	1.89	55.1	Improved by washing.
,256	229	.27	.78	82.97	15.98	.82	.087	1.89	42.5	Improved by washing fine coal.

Coking tests—Continued.

Name of sample.	Coal.							
	Condition.	Chemical composition.					Amount charged in oven.	Coking time.
		Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.		
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Pounds.*	*Hours.*
West Virginia No. 6A	Raw	1.76	21.48	71.92	4.84	.55	13,000	90
West Virginia No. 6B	do	2.27	22.03	70.30	5.40	.88	9,000	66
West Virginia No. 6C	Raw, fine	1.73	21.12	71.57	5.58	.64	8,000	44
West Virginia No. 7	Raw	3.85	20.55	70.58	5.02	1.36	8,000	44
West Virginia No. 8	do	3.82	31.77	57.21	7.20	.89	11,000	66
West Virginia No. 9	do	3.81	31.08	57.04	8.07	.83	10,000	40
Do	Washed	5.74	32.14	57.61	4.51	.90	11,000	66
West Virginia No. 10	Raw	1.61	18.39	74.65	5.37	.61	11,000	68
West Virginia No. 11	do	3.35	15.94	68.76	9.95	.47	11,000	67
West Virginia No. 12	do	1.53	18.23	74.08	6.16	.97	11,000	68
Do	Washed	8.36	18.20	68.54	4.90	1.11	8,000	44

Coking tests—Continued.

Coke.										
Amount produced.	Breeze and ash.	Chemical compositions.						Specific gravity.	Per cent produced.	Remarks.
		Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Phosphorus.			
Lbs.	*Lbs.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*			
8,303	381	2.83	2.17	89.84	5.16	.69	.008	1.77	63.9	Gray, soft and light.
6,399	382	.36	1.34	93.04	5.24	.76	.007	1.87	71.1	Better than A.
5,849	273	1.89	1.83	88.80	7.48	.69	.006	1.79	73.1	Dense, tough.
5,119	287	.67	1.23	90.40	7.70	1.03	.0061	1.80	64.7	Good coke.
7,124	589	2.79	.53	82.37	14.31	.77	.0116	1.92	64.7	Hard, good color.
6,084	314	.29	2.41	88.15	9.15	.82	.0094	1.84	60.8	Fair coke, heavy.
6,803	78	.27	.62	91.73	7.38	.77	.012	1.87	61.8	Very good coke.
7,858	429	3.68	.53	87.54	8.25	.56	.007	1.89	71.4	Good coke.
......	......	......	......	......	......	......	......	......	......	Burned to ash.
7,082	549	.35	.85	89.37	9.43	.83	.0077	1.95	64.4	Fair coke.
5,050	583	5.16	.72	86.57	7.55	1.01	.01	1.88	63.1	Large pieces.

BRIQUETTING TESTS.

By Joseph Hyde Pratt.

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The writer was very ably assisted by Mr. A. A. Steel, who superintended most of the experiments made on the regular briquetting machines and conducted almost all of the laboratory work. Material assistance was also rendered by Mr. Charles H. Smith in suggesting ways and means and in actual experimental work about the plant. The success of the work is largely due to the Barrett Manufacturing Company, of St. Louis, and the Chatfield Manufacturing Company, of Carthage, Ohio, for supplies of pitch of various grades for binders; to Mr. C. C. Hawkins, chemist of the Chatfield Manufacturing Company, for suggestions and information regarding pitch, its analysis, etc.; and to Dr. Herman von Schrenk, of the Bureau of Forestry, for assistance in the rational analyses of pitch.

BRIQUETTING PLANT.

The briquetting plant consisted of two machines of distinctly different types. One of the machines was furnished by William Johnson & Sons, of Leeds, England, and is designated in this report the English machine. This machine is one of the standard types for briquetting with stiff pitch, and consists of a double compression, vertical table press with closed molds and its accessories. It was operated by a 50-horsepower inclosed motor, which was furnished by the Westinghouse Electrical Manufacturing Company, of Pittsburg, Pa.

The second briquetting machine was furnished by the National Compressed Fuel Company, of Chicago, Ill., and consisted of a Chisholm, Boyd & White press, constructed on Belgian patterns and its accessories. This is ordinarily known as the eggette machine or press, but is designated throughout this report the American machine. It also was operated by a 50-horsepower motor, furnished by the Westinghouse Company.

ENGLISH MACHINE.

In operating the English machine the coal is delivered from the washer or drier by an inclined conveyor, furnished by the Robins Conveying Belt Company, and received upon a slightly raised plat

orm, holding about 10 tons, from which it can be conveniently shoveled hrough a hole in the same floor onto a coal-feeding worm. At the ame time the pitch which is used as a binder, having been first reduced o a suitable size, is fed into the pitch cracker, which reduces it to a alf-inch size and drops it to a smaller worm, and this in turn delivers t onto the coal in the larger worm. The smaller worm is driven by prockets from the larger one, and the percentage of pitch that is dded to the coal can be varied by changing the wheels.

While this arrangement gives good results when the same coal and inder are used, it is not sufficiently flexible to be adapted to the differnces in behavior of the various coals and binders that were used in he experimental work; and therefore, for most of the experiments, he crushed coal and cracked binder were weighed out on Fairbanks cales and mixed by hand. The mixed coal and binder were then fed hrough the hole in the floor onto the larger worm.

After a slight mixing in the larger worm, the material enters an mpact disintegrator, in which it is reduced to the desired degree of ineness. The speed of the disintegrator is varied according to the haracter of the coal. This is accomplished by running either one or oth sides of the disintegrator and by tightening or slacking the belts. From the disintegrator the well-mixed, finely divided mass is elevated o a pug mill, about 5 feet in vertical height, in which the pitch or ther stiff binder is softened by contact with live steam. As there is o attachment on this machine for introducing or utilizing superheated team, the range of temperatures in which the binder could be softened vas very limited. Then again, live steam is apt to be wet, and in such nstances it would often be a detriment to the production of successful riquettes.

From the pug mill the plastic mixture falls by gravity to the feed ox of the press, from which it is forced by a plunger into brass-lined nolds in a vertical revolving table. After a half revolution of the able the mass in the mold is heavily pressed by a system of combined evers, the pressure being limited to 2 tons per square inch by the ielding of a stiff spring. This pressure, however, can be varied from few pounds up to 2,000 pounds as a maximum.

After another quarter revolution the briquettes are forced, by neans of a plunger, out of the molds on a slide or table set at a conenient height for stacking on trucks. In the experimental work at he plant the briquettes were taken from the slide or table by hand as oon as they were discharged from the press and stacked on a platform ust outside the building. The briquettes, as they come from the nachine, are rectangular, except for rounded corners, and weigh on he average 6.8 pounds each, the weight varying with the coal and inder used. The maximum capacity of this press is 6 tons of riquettes per hour.

This machine is adapted only to those binders which do not become plastic before reaching the pug mill, and in the experimental work the smallest quantity that could be made and at the same time give a satisfactory test to the coal and binder was 1 ton.

AMERICAN MACHINE.

In operating the American plant the coal is received from the Robins conveyor at the level of the second floor in a bin of 3 tons capacity. From this it is spouted to a 500-pound bin on a Fairbanks platform scale, from which it passes into the boot of an elevator that hoists it up and drops it into a 15½ cubic foot measuring box. The coal is then dumped into a Buffalo mixer fitted with steam jackets for warming the coal and the binder. The binder is melted in a small steam jacketed tank entirely distinct from the main part of the machine, from which it is dipped by hand in the desired proportion and poured into the mixer. After a thorough mixing the mass is dropped into the feed slides of the press. This tangential press consists of two pairs of narrow-faced rolls, in the tores of which are ovoid cups for receiving the mixture to be pressed. As the rolls revolve the excess material is squeezed out, the resulting pressure being dependent upon the viscosity of the mixture that is being compressed. The eggettes are delivered from the press on a short rubber belt, and they weigh on an average about 0.3 of a pound each.

The capacity of the press is fully 5 tons of eggettes per hour, but the output of the mixing device was much too small for operating the press at its full capacity. As arranged, this machine was adapted for the use of soft binders only, and it was necessary to grind the coal at the washery. For experimental work, however, it had one advantage over the larger English press, inasmuch as it permitted the testing of mixtures in lots as small as 15 pounds. In making these small tests a 35-gallon camp kettle was employed for heating the mixture. It was also possible to test on the American machine the mixture used in the English machine by crushing up some of the hot briquettes as soon as they were received from the molds and transferring the material at once to the feed box of the American machine.

BINDERS.

The materials that have been tried as binders in the laboratory experiments and on the two briquetting machines include the following: Pitch of various grades; creosote; asphalt, hard and soft, crude and refined; asphaltic pitch; petroleum, both of paraffin and asphalt bases; molasses; lime, and clay.

PITCH.

Pitch is the residue left from the distillation of tar, which is produced (1) from by-product coke ovens; (2) from illuminating-gas plants; (3) from producer-gas plants; (4) from pintsch gas tar; (5) from wate

gas plants, and (6) from petroleum gas tar. Pitches made from the first three varieties of tar were tested, and each gave practically as good satisfaction as the other when approximately of the same composition. Petroleum gas tar gave the best results.

There was considerable variation noticed in the pitches that were submitted to the plant for the experimental work, and at the beginning it was difficult to obtain the grade that was desired. The first pitch received was from the St. Louis works of the Barrett Manufacturing Company. The pitch was too hard and would not soften at a sufficiently low temperature to be used satisfactorily in either the English or the American machine. It was subsequently proved that the pitch did not contain a sufficient quantity of the creosote oils to give it the required binding qualities. This pitch is designated *pitch A* throughout this report. The second lot of pitch was received from the Chatfield Manufacturing Company, of Carthage, Ohio. It was harder than pitch A, indicating that a still greater per cent of the creosote or adhesive oils had been driven off. Although these pitches would make briquettes, it was necessary to use from 13 to 18 per cent of them, while of a good, satisfactory pitch it required only from 6 to 9 per cent with the same coal. This pitch is designated throughout the report *pitch X*.

In order to determine the quality of pitch that would be satisfactory, some of the best tar from the producer-gas plant was heated until all of the water was expelled. The boiling was continued until, when the residue was dropped into water having a temperature of 55° F., it became brittle. After bucking down, this pitch stuck together on standing one week in the laboratory. It is known throughout this report as *pitch Z*. A long series of tests was then made with this pitch upon various coals, and it was found that 6 per cent of it made better briquettes than 13 per cent of *pitch X*. In order to further demonstrate the necessity for pitches of the right quality to contain a higher percentage of the creosote or adhesive oils than pitches A or X, experiments were made with hard pitch A and water-free producer-gas tar. These were melted together in various proportions until a product was obtained which, when dropped into water at 55° F., would become brittle. A sufficient quantity of this product was made to briquette 2 tons of coal, and it was found to give the results desired, showing that it is necessary for a pitch to contain a certain percentage of these creosotes or adhesive oils. This pitch will soften when held in the mouth; when it is first bitten it cracks and crumbles like spruce gum, but almost immediately becomes plastic and can be chewed like ordinary gum. This pitch is designated throughout this report *pitch Y*.

Samples of this pitch were sent to the Barrett Manufacturing Company and the Chatfield Manufacturing Company, and pitch of the right

quality was obtained in quantity. The pitches that were received from the Barrett Manufacturing Company are designated in this report *pitches B*, *C*, and *D*. Those received from the Chatfield Manufacturing Company are known as *pitches E*, *F*, and *G*.

Another pitch that was furnished by the Barrett Manufacturing Company was obtained as a by-product from the manufacture of gas from heavy petroleum. When hot, this pitch has a marked odor of kerosene, but it would not mix with Kansas crude oil. It is lustrous and works well on a cool day, but is a little too soft in ordinary weather for experimenting on the English machine. This pitch is designated *pitch H* throughout this report.

Analyses have been made of the pitches A, B, C, D, E. F, G, H, and X by Mr. E. E. Somermeier, in charge of the chemical laboratory of the testing plant, with the following results:

Proximate analyses of pitches.

Pitch.	Laboratory No.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Total.
A	1161	0.47	47.93	50.79	0.81	[a] 0.80	100.80
B	1311	1.14	49.66	47.88	1.32	.70	100.70
C	1391	.88	62.75	35.84	.53	....	100.00
D	1465	1.45	54.05	43.91	.59	....	100.00
E	1464	1.02	54.11	44.04	.83	....	100.00
F	1457	.57	52.98	45.31	1.14	....	100.00
G	1453	.60	52.53	45.62	1.25	....	100.00
H	1555	1.04	61.44	36.72	.80	....	100.00
X	1125	.33	59.07	39.44	1.16	.88	101.38

[a] Approximately determined.

Ultimate analyses of pitches.

Pitch.	Laboratory No.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Sulphur.	Calorific value.
A	1161	....	....	....	....	0.80	....
B	1311	3.97	90.89	1.05	2.07	....	8,78
C	1391	4.72	91.16	1.16	1.85	.58	8,93
D	1465	4.28	91.57	1.10	....	....	....
E	1464	4.22	91.30	1.00	....	....	....
F	1457	4.16	91.50	1.00	....	....	....
G	1453	4.06	90.82	1.01	....	....	....
X	1125	4.56	90.34	.99	2.07	.88	8,8

Although no definite conclusions can be drawn from the results of the analyses given above, it is apparent that for pitches distilled from the same tar, under the same given conditions, those with the highe

percentage of volatile matter give the best results in briquetting. There may be, however, a wide variation in the percentage of the volatile matter in two pitches made from different tars and distilled under different conditions and yet the pitches may have approximately the same quality for binding purposes.

In order to obtain something more tangible regarding the composition of the pitches in respect to their binding qualities and value in briquetting, a series of tests was made by distilling off thin volatile products. For this purpose a small copper still was constructed and the distillations were made in the laboratory of Dr. Herman von Schrenk. In carrying out these experiments, 200 grams of the pitch were placed in the still, and this was heated gradually until there was nothing left but a coke residue. In every instance at a temperature of 400° all of the volatile matter had been driven off and the residue was hard coke. The results of these distillations are given in the table below:

Distillation of pitches.

Pitch.	Laboratory No.	Quantity of pitch used.	Temperature at which first drop came over.	Temperature at which the last of the oil was observed to come off.	Percentage of oil.	Final temperature to which still was raised.	Residue.
		Grams.	°	°		°	
[illegible]	1161	200	380	385	1.36	400	Hard coke.
[illegible]	1311	200	351	....	7.38	400	Do.
[illegible]	1465	200	332	375	13.01	400	Do.
[illegible]	1464	200	350	370	1.91	400	Do.
[illegible]	1453	200	324	382	.96	400	Do.
[illegible]	1125	200	391	....	.71	400	Do.

The above experiments show that from 7½ to 14 per cent of these oils is necessary in the pitches in order to give them the binding qualities that are desired in briquetting. With a higher percentage of oils the pitches become too soft and can not be used to so good advantage. Then again, the oils that are driven off from 315° and under are the creosote oils. Creosote was used to mix with some of the hard pitches for binding purposes and gave satisfactory results.

ROSIN.

The cheaper grades of rosin can be used for binding purposes to as good advantage as the refined material, and, as far as could be judged from the work done in the laboratory, the crude, black rosin will give as good satisfaction as the partially refined. Rosin in some cases can

be used to advantage for hardening purposes as well as for its binding qualities. It has been used with lime and pitch, and good briquettes were made from this combination. In using rosin and pitch as a binder it was found that a smaller percentage of these two together was required to give either as good or a better briquette than when pitch was used alone. In burning there is little or no odor from the rosin, although there is some tendency to smoke.

ASPHALT.

The asphalt used in the experimental work consisted of a California refined asphaltum of grade B, which is designated throughout this report *asphalt B1*. Another asphalt product used is known as "kopak" No. 30, manufactured by the Raven Mining Company, of Texas, and is of a rubbery consistency. This is known as *asphalt B2*. An asphaltic pitch manufactured by the Standard Oil Company at one of its Texas plants also was used, and it is known as *asphalt B3*. Crude asphalt from Indian Territory is known as *asphalt B4*. This asphalt is altogether too hard, approaching close to a coke, and containing but a very small percentage of volatile matter.

A soft asphalt was received from the Gulf Refining Company o Port Arthur, Tex., and is designated throughout this report *asphal B5*. An analysis of this asphalt by Mr. E. E. Somermeier was a follows:

Analysis of soft asphalt from the Gulf Refining Company.

	Per cen
Moisture	0.
Volatile matter	80.7
Fixed carbon	19.
Ash	0.
Total	100.

Another soft asphalt was furnished by Mr. John McNeil from Ca per, Wyo., and is known throughout this report as *asphalt B6*. It a soft, tough asphalt, which on cooling to about 40° became brittl An analysis by Mr. E. E. Somermeier gave the following results:

Analysis of asphalt from Casper, Wyo.

	Per ce
Moisture	0.
Volatile matter	78.
Fixed carbon	20.
Ash	0.
Total	100

PETROLEUM.

Petroleum, of both paraffin and asphaltum bases, can sometimes used to advantage in briquetting. On account of lack of time l little experimenting was done with the petroleums. Those that h

been used were crude oil from Spindletop, Tex., which was produced by the Gulf Refining Company, and a petroleum from the Beaumont district, having a specific gravity of 15, flash test 505, and fire test 570, which was produced by the Great Southern Refining Company. These are designated *P1* and *P2*, respectively, throughout this report.

The only other oil that was tested in briquetting was a Kansas crude oil, which is designated throughout this report *P3*.

MOLASSES.

A few experiments were made with molasses in order to determine the possibility of utilizing waste products from sugar and beet refineries in briquetting lignite and lignitic coals that occur in the vicinity of sugar refineries. Although no positive results have been obtained with the use of this binder, the work has shown the probability that such waste products can be utilized in connection with certain other materials to give a satisfactory binder.

LIME.

Lime has been used in combination both with rosin and with molasses, and some encouraging results were obtained. One of the main objections to using more than a very small amount of lime is the fact that it increases the percentage of ash in the fuel without raising its heating efficiency. On the other hand, however, it is one of the cheapest of binders, and in most cases is convenient to the coal districts.

CLAY.

A few experiments were made with clay in combination with other compounds in an attempt to obtain a suitable binder for lignitic coals, but without success.

LABORATORY EXPERIMENTS.

In testing the value of the various binders for briquetting coal, a series of experiments was made with each in the laboratory by briquetting the mixture in a hand press. The mixture of coal and binder was heated in a clay assay crucible over a Bunsen burner. In most cases they were heated only to about 212° F., but where the binder was softened with difficulty the temperature was increased.

PITCHES.

Special experiments were made with the different pitches, A, B, C, etc., and where there was considerable variation in their composition a more nearly complete series of experiments was made. When, however, the pitches were similar, as B, C, and D, the series of experi-

ments made with one was significant of what could be done with the others.

Pitch A.—A series of experiments was tried in the laboratory with pitch A in order to determine its binding qualities. It was found that the best practical results were obtained with 9 per cent of this hard pitch on an easy briquetting coal, but with the other coals the percentage would be very much higher.

Pitch B.—This pitch was tested with West Virginia coking coal. With 3 per cent of pitch B a fair briquette was obtained. With 4 per cent the resulting briquette was a little better. With 5 per cent, however, a good briquette was obtained, which had the desired lustrous fracture. With Arkansas coal it required 6 per cent of this pitch to give the desired results; and as this coal represented more nearly the character of the coals to be briquetted, this was accepted as the percentage required of this and the similar pitches, C and D, to make a good briquette.

Pitches C and D.—These, which are very similar to E, were usec from the formulas derived for B, and in nearly all cases the runs made on the English and American machines were satisfactory.

Pitch E.—This pitch, which melts at 180° F., is a trifle too hard fo satisfactory briquetting on the English machine, and is not equal t pitch B, C, or D.

Pitch G.—This pitch, which melts at 196° F., is too hard (simila to A and X) to be used alone in briquetting.

Pitch X.—This pitch, which contained only 0.71 per cent of volatil matter, was tested with a number of coals and it required from 13 t 20 per cent to make a briquette that was at all coherent.

Pitch Z.—The producer-gas pitch Z was tested with Arkansas coa 6.7 per cent of the pitch being used. While hot both of these br quettes were soft, but on standing one hour they became very hard an had a glossy or lustrous fracture. When tested in the muffle the burned without disintegration.

A series of experiments was made which indicated that there is r advantage in using lime with pitch in an attempt to reduce the pe centage of pitch that it is necessary to use. With, however, tl introduction of some third reagent which would react with the lin it is possible that a binder could be produced which would be cheap than pitch alone and be as satisfactory.

ASPHALT.

In experimenting with the asphalts, they were used alone as a bind and also in combination with other compounds. There were a nu ber of satisfactory results obtained in the laboratory work, but only very few of these could be tried on the English or American machir on account of their construction.

California asphalt, B1.—This asphalt is brittle at ordinary temperatures and can be readily disintegrated. At 212° F. it softens slightly, and it is soft and very sticky after melting. This asphalt mixes readily with the Spindletop (Tex.) petroleum, P1, and the residual product of Beaumont petroleum, P2, in all proportions, and can therefore be thinned to any consistency. A series of experiments was made with this asphalt, which indicates that to obtain the best results it would be necessary to heat the mixture with superheated steam or to add crude oil.

Asphalt product (kopak), B2.—This Texas asphaltic compound is of a rubbery consistency at ordinary temperatures, and at 212° F. only softened slightly without becoming sticky. It melted at a rather high temperature, was still rubbery, but very adhesive. Alone it can not be disintegrated readily, but in a cold temperature it can with some care be crushed. It is not affected by the crude Spindletop (Tex.) oil, P1, or the residual petroleum from the Beaumont district, P2. With the warm asphaltic pitch it mixes readily, and but little of this pitch is needed to make a soft and sticky mass. With ordinary coal-tar pitches this asphaltic compound will not mix at all. With rosin the rubbery asphalt mixes readily, and the resulting product can be cracked easily, and it is very strongly tenacious and somewhat elastic. This asphalt has the qualities that should make it a desirable binder, and it may be found useful in briquetting lignites.

Asphaltic pitch, B3.—This asphaltic pitch, made by the Standard Oil Company at one of its Texas plants, was found to have excellent binding qualities and to be of the right consistency to work easily. It makes a tough and elastic briquette, but apparently it does not give the degree of hardness that can be obtained from the pitches made from coal tar.

A series of experiments was made with this pitch in combination with rosin. The briquettes made from 4 per cent asphaltic pitch and 2 per cent rosin and from 3 per cent pitch and 3 per cent rosin were of equal value; but as the 3 to 3 briquette would probably be the cheaper, it has been adopted as the standard ratio for this asphaltic pitch and rosin.

Indian Territory asphalt, B4.—This asphalt does not soften at all in boiling water, even when tested as powder. It melts to a stiff, sticky liquid rather suddenly just below its ignition point, which is at a very high temperature. It is only slightly soluble in gasoline. At the boiling point there is apparently no reaction between this hard asphalt and crude Kansas petroleum, P3, or the Spindletop oil, P1, or the Beaumont residual petroleum, P2. Neither is there any apparent action between this asphalt and melted rosin. With creosote it softened materially, and when used in the ratio of 5 per cent of each with Arkansas coal a fair briquette was obtained. With Pintsch gas

tar an apparent reaction took place, which caused the separation of some of the intrained water. This asphalt was tried alone with Arkansas coal, 4 per cent of asphalt being used, and even when heated dry at a high temperature the resulting briquette was poorly coherent. With 6 per cent of asphalt the briquette was little or no better, indicating that the asphalt alone has no binding properties, as was supposed from the very small amount of volatile matter that it contained.

Wyoming asphalt, B6.—This asphalt united readily with rosin, and in preparing a mixture for briquetting 2 parts of asphalt and 1 part of rosin were melted in a kettle and cooled over night. On a cool, frosty day this mass was very brittle, but became sticky with a rise in temperature. In using the mixture 1 to 2 parts of lime were added to prevent its becoming too soft while hot. The briquettes made from this mixture were all right in appearance, but in burning they crumbled easily, not standing up well in the fire.

In testing this asphalt alone it was necessary to heat the coal in an assay crucible, adding the fragments of asphalt and kneading them together with repeated heatings. Six per cent of this asphalt alone would make a strong, tough briquette with Wyoming lignite, which was slightly earthy in appearance. When tested in the fire, however, the briquette fell to pieces at once and completely.

ROSIN.

In using rosin alone it was found to make hard, brittle briquettes, but they were not satisfactory, principally on account of their brittleness, which would prevent their standing rough treatment in transportation. The results of the tests made with rosin and pitch have been recorded under "Pitch." Rosin mixes with almost all the crude oils and their residual products which have been tested in the laboratory. With the rubbery asphalt, B2, it mixes readily, forming a stil more rubbery mass. With the Indian Territory, B4, it does not unit at all. All of the oils and petroleums increased the toughness of th rosin, and the resulting masses varied from the consistency of wago grease to sticky rosin. Five parts of rosin melted with 1 part o Kansas crude petroleum gave a tough mass that could just be cracke when cold, and this seemed to be the best ratio for these two com pounds. With lime alone it was found that 15 per cent of lime and 8 per cent of rosin were required for a complete reaction. Rosin wit unslacked lime sets after melting. If the slacked lime is used th action occurs at 212° F. and the mass is light gray. This cemen softens and becomes sticky only at the melting point of lead. On coo ing it is brittle, but stronger than rosin. With slacked lime rosi reacts and gives a satisfactory mixture up to 3 parts of rosin and 1 part of slacked lime. A combination of rosin and the residual Bea mont petroleum, P2, was made considerably tougher by the additio

of lime, and for this relatively more lime is needed than when used with rosin alone. The best combination obtained was 6 parts of rosin to 3 parts of slacked lime to 2 parts of the petroleum, P2. With Kansas crude oil no positive results could be obtained. Six parts of rosin, 3 of lime, and 4 of the Kansas oil, P3, gave a greasy granular mass without any apparent binding properties. With 3 parts of oil instead of 4 a sticky mass was obtained, which, however, had no strength.

PETROLEUM.

All the crude oils and petroleums can be stiffened to some extent by mixing with rosin or hard pitch. None of the petroleums and oils that have been tested, however, could be used alone in briquetting any of the coals. Most of them were too fluid and had little or no binding qualities.

MOLASSES.

The molasses experimented with in the laboratory was that which can be bought in any market. In using the thick molasses it was found advantageous to dilute it with twice its weight of water, and the lime was slacked to a paste with twice its weight of water. When these two reagents were mixed together they had no apparent reaction until dried out. Using 1 part of water to 1 of molasses and 2 of lime, there was no apparent excess of either, and the mixture set at once to a rather hard cement, similar to plaster of Paris. A series of experiments was made with Arkansas coal, which showed that 5 parts of molasses to 1 of lime would give the best results.

WAX TAILINGS.

A sample of wax tailings was received from the Standard Oil Company, which was tested with Arkansas coal. With 2 per cent of wax there was no coherence between this and the coal under moderate pressure. With 4 per cent, either hot or cold, an elastic briquette was obtained which was fairly clean, but yielded under pressure applied slowly. These briquettes were burned in a scorifier placed in a muffle, and they seemed to burn perfectly. With pressure a briquette with 4 per cent was obtained which had no greater strength than the other, but was very smooth and clean. With 5 per cent of the wax and with light pressure a briquette was obtained that was rather sticky, and there was undoubtedly an excess of wax, as was indicated by its sticking to the plunger.

The wax was also tried with some of the harder pitches. With 1 per cent of wax and 3 per cent of pitch X a briquette was obtained that had no coherence whatever. With 1 per cent of wax and 5 per cent

of pitch the resultant briquette had no coherence, regardless of what pressure was used. With 2 per cent of wax and 4 per cent of pitch X a briquette was obtained which was similar to the one in which 13 per cent of pitch X alone was used. It was, however, not a satisfactory product.

ACID SLUDGE.

Some acid sludge was received from the Gulf Refining Company, of Port Arthur, Tex. It was mixed with water, and the resultant solution was a weak acid which did not seriously attack iron. Part of this sludge was a thin, greasy mass and the remainder was of a rubbery, granular consistency. When these were heated together to the melting point they did not mix, and on cooling they separated into the same two parts. The stiffer portion of the mixture will mix with melted rosin, and the resultant mass resembles the rubbery petroleum, B2. On account of lack of time no further work was attempted with this acid sludge.

LIME.

No experiments were made with lime alone, as the percentage required for making a briquette that would hold together was so high that it precluded entirely its use as a binder. The principal use of the lime was with rosin and molasses, and these experiments have been described under those heads.

CLAY.

Clay alone was tried up to 8 per cent, but in no case was a briquett obtained that would hold together on drying, although the clay use was a superier potter's clay. In making the laboratory briquettes th clay was used only in connection with lignite, in order to determin its effect on the strengthening of the briquettes so that they woul hold together in burning. With 2 per cent of clay there was little o no effect noticed in the resultant briquette when rosin and the petro leum, P2, were used. With 4 per cent of clay the quantity of th other two required was reduced from 6 per cent each to 5½ per cen each, and the briquettes that were made from this mixture he together somewhat better in the fire. On account, however, of th large increase in the percentage of ash caused by the clay no furth tests were made with a higher percentage of clay.

BRIQUETTES MANUFACTURED.

According to the results obtained in the laboratory, briquettes quantity were made on either the English or the American machi from the following coals:

LIST OF COALS BRIQUETTED.

(1) Alabama No. 1. Bituminous lump and nut coal from mine No. 8 of the Ivy Coal and Iron Company, Horse Creek, Ala.

(2) Arkansas No. 1. Bituminous lump and nut coal from mine No. 3 of the Central Coal and Coke Company, Huntington, Ark.

(3) Arkansas No. 2. Bituminous lump coal from mine No. 12 of the Central Coal and Coke Company, Bonanza, Ark.

(4) Arkansas No. 3. Bituminous lump and slack coal from mine No. 18 of the Western Coal and Mining Company, Jenny Lind, Ark.

(5) Arkansas No. 4. Semibituminous slack coal from several Arkansas mines, furnished by the Western Coal and Mining Company, St. Louis, Mo. The coal came principally from mines 1, 2, 3, and 4, near Denning, Ark.

(6) Arkansas No. 5. Semibituminous lump and slack coal from mine No. 4 of the Western Coal and Mining Company, Coal Hill, Ark.

(7) Arkansas No. 6. Bituminous slack coal from mine No. 18 of the Western Coal and Mining Company, Jenny Lind, Ark. This is from the same mine as Arkansas No. 3.

(8) Colorado No. 1. Run-of-mine black lignite from the Simpson mine of the Northern Coal and Coke Company, Lafayette, Colo.

(9) Illinois No. 1. Bituminous lump and nut coal from mine No. 1 of the Western Anthracite Coal and Coke Company near O'Fallon, Ill.

(10) Illinois No. 4. Bituminous lump coal from mine No. 3 of the Donk Brothers Coal and Coke Company, Troy, Ill.

(11) Indiana No. 1. Bituminous run-of-mine coal from the Mildred mine of the J. Woolley Coal Company, Mildred, Ind.

(12) Indiana No. 2. Bituminous run-of-mine coal from the Electric mine of the T. D. Scales Coal Company, Boonville, Ind.

(13) Indian Territory No. 2. Bituminous run-of-mine coal from mine No. 8 of the Rock Island Coal Company, Hartshorne, Ind. T.

(14) Indian Territory No. 3. Bituminous run-of-mine coal from mine No. 1 of D. Edwards & Son, Edwards, Ind. T.

(15) Indian Territory No. 6. Bituminous slack coal from mine of the Southwestern Development Company, Coalgate, Ind. T.

(16) Iowa No. 4. Bituminous lump coal from mine No. 3 of the Centerville Block Coal Company, Centerville, Iowa.

(17) Kansas No. 2. Bituminous lump, nut, and slack coal from mine No. 11 of the Western Coal and Mining Company, Yale, Kans.

(18) Kentucky No. 1. Bituminous run-of-mine coal from Straight Creek mine No. 2 of the National Coal and Iron Company, Straight Creek, Ky.

(19) Kentucky No. 2. Bituminous lump, nut, and pea coal from mine No. 11 of the St. Bernard Mining Company, Earlington, Ky.

(20) Missouri No. 1. Bituminous run-of-mine coal from New Home mine No. 1 of the New Home Coal Company, Sprague, Mo.

(21) Montana No. 1. Washed bituminous coal from mine near Red Lodge, Mont.

(22) New Mexico No. 1. Black lignite from Weaver mine of the American Fuel Company, 3 miles north of Gallup, N. Mex.

(23) New Mexico No. 2. Black lignite slack from the Otero mine of the Caledonian Coal Company, 2 miles east of Gallup, N. Mex.

(24) North Dakota No. 1. Run-of mine brown lignite from Lehigh, N. Dak.

(25) Pennsylvania No. 3. Anthracite culm from Pennsylvania Coal Company, Scranton, Pa.

(26) West Virginia No. 6. Bituminous run-of-mine coal from mine of the New River Smokeless Coal Company, Rushrun, W. Va.

(27) Wyoming No. 1. Black lignite from mine of the Wyoming Coal and Mining Company, located at Monarch, Wyo.

The above coals have been tested with various binders on both the English and American machines, and from a ton up to 15 tons of briquettes have been made from each coal. In the following pages is given a description of the binders used, of the character of the briquettes as they were received from the machine and after they were exposed to the atmosphere, and of their behavior when burned. These descriptions are taken up alphabetically by States.

ALABAMA.

Alabama No. 1.—This is a coking coal which can be very readily manufactured into a briquette with hard pitch, and which under extreme pressure can be briquetted without the addition of any binder. There were 4.5 tons of this coal briquetted on the English machine with 7 per cent of the hard pitch A. The briquettes were strong and quite satisfactory, except for porosity due to a lack of sufficient pressure. These briquettes stood up well in the fire,[a] but on long exposure to the weather became somewhat disintegrated. The weight of the briquettes averaged 5⅛ pounds each.

ARKANSAS.

All of the Arkansas coals tested are similar in their properties. They are higher in fixed carbon than the ordinary bituminous coal and are often called semianthracite coals. The coals from Jenny Lind and Denning show more of this character than the coals from the other sections of Arkansas.

Arkansas No. 1.—This coal was tested only with hard pitch A, as this was the only pitch available at the time the coal was briquetted. Six tons of coal were mixed with 9.25 per cent of this pitch and made into briquettes on the English machine.[a] The briquettes were compact and well pressed, but were too friable for handling, showing that there was not sufficient pitch. They were brownish in color and very dirty. Judging from the results obtained in working with other Arkansas coals, this coal will require more than the usual amount of pitch.

Arkansas No. 2.—This coal was tested with the very hard pitch [illegible] which at the time was the only pitch available. These briquettes were made in the English machine, which was set to give approximately [illegible] per cent pitch. There were 6 tons of crushed lump coal run through the machine, but the resultant briquettes were very pitchy and wr[illegible]

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[a] For steam test see p. 80.

led and probably contained nearer 15 per cent than 11 per cent pitch.[a])n account of the difficulty of setting the machine to feed accurate ercentages of pitch to the coal, the experiments were conducted for ıe most part after this by weighing out the determined quantities f coal and pitch by hand. Pitch X, on account of its hardness, set ›o quickly in the molds, so that the briquettes were insufficiently ressed and apt to be porous.

Arkansas No. 3.—This coal was briquetted without running it ırough the drier with 9.5 per cent of the hard pitch X, which was ›und to be plenty for this coal. The coal was slightly moist, which ıade it in just the right condition to pass readily through the machine ʻithout clogging the elevator. The coal was very friable and was educed to almost a flour in the disintegrator. The briquettes had ery smooth, polished surfaces, having received the greatest pressure ıat could be obtained from the machine. Some of the briquettes, as ıey were received from the machine, were cracked perpendicularly › the pressure, which may have been due to an excess of pressure. hese briquettes weighed on an average 6.8 pounds each.

This coal was also tested with the somewhat softer pitch A. One ›n of the coal was mixed with 8.7 per cent of pitch. A large excess f steam was introduced into the pug mill so as to soften the pitch as uch as possible. The briquettes were smooth and easily handled, ıt somewhat pitchy, showing that there was an excess of pitch. nder the same conditions of heat and pressure, 7.5 per cent of pitch would have been sufficient, and if a good pitch were used a still naller amount would make a good commercial briquette. These iquettes ignited readily and did not disintegrate in the fire until ey were consumed.[a]

Arkansas No. 4.—This consisted of slack coal, which was soaking et when received, and it had to be passed through the drier before it uld be used. When dried, it was so brittle that the disintegrators the English machine reduced it to flour, so that it choked up the evator and other parts of the machine. The first run made of this ied coal contained 12 per cent of hard pitch X, and although the iquettes when first received from the machine were very compact d smooth, they were incoherent and unsatisfactory and on exposure the weather very soon began to disintegrate more or less and became iable. The next test on this very finely divided coal was with pitch . One ton was mixed with 10 per cent of pitch. The press was run ster, not only to make the pressure greater, but also to give the rd pitch less time to set in the machine. At the same time the dis-tegrator was run slower in order not to reduce the coal to so ıe a condition. The briquettes were very pitchy, but owing to the cess of water from the condensation, many cracked when the

[a] For steam test see p. 80.

pressure was relieved. Another ton of coal with 8 per cent of pitch A contained too much binder, and another ton was made with 6 per cent. These latter briquettes were compact and well pressed, but did not contain enough binder. Seven per cent of pitch A gave a better result than either 6 or 8.

Another run of this coal was made with 3 per cent rosin and 2 per cent of pitch A as a binder. The briquettes were very clean and sharp in outline, but were somewhat brittle and had a tendency to break into large fragments. They were, however, physically better than those with 6 or 8 per cent of pitch alone. In burning, they held together very well, but smoked more than those with pitch alone, but no odor of rosin was given off. This same mixture was tested on the American machine, which gave clean, polished briquettes, which were stronger than those made on the English machine, indicating that rosin works to better advantage in the smaller and more rounded briquettes.

A ton of this coal was briquetted by using 3 per cent of rosin and 3 per cent of pitch A. This mixture made excellent briquettes, which were usually clean and with sharp edges. It was also tried on the American machine and gave exceedingly smooth and lustrous eggettes, which were stronger than the large briquettes made on the English machine. The eggettes were tested in a cook stove, where they burned very satisfactorily without any odor, but gave off considerably more smoke than either coal or briquettes made from pitch alone as a binder.

This coal was further tested with the softer pitch B, which was on of the better pitches for briquetting. One ton was first made with per cent of pitch, and the briquettes were clean, sharp, and apparentl considerably stronger than the original lump coal. These were th first commercial briquettes made at the plant. They were capable o standing very rough handling. In weight they averaged 7 pounc each, and their specific gravity was 1.17. On the American machin this same mixture gave polished eggettes, but they were not so stron as those made on the English machine. Pitch B was then tried wi rosin, the proportions being 95 per cent of coal, 3 per cent rosin, a 2 per cent pitch. On account of the condensation of steam in the p mill, there was considerable excess of water in the briquettes, whic however, were smooth and sharp when received from the press. T excess of moisture caused them to crack badly, and they were diffic to handle while fresh. After cooling, they were still soft, and th were noticeably inferior to the briquettes made with 3 per cent rosin and 2 per cent of pitch A. They weighed 7.2 pounds each. T mixture also was tested on the American machine, which made har eggettes than the corresponding briquettes of the English machi This is a further confirmation of the supposition that the smaller a rounder form is better adapted for the rosin binder and will result a harder and tougher briquette.

The manufacture of briquettes from Arkansas No. 4 coal and 6 per cent of pitch B as a binder is commercially feasible. Six tons of this coal were briquetted with 6 per cent of pitch B, with which to make a boiler test.[a] A portion of these briquettes were made by running but one side of the disintegrator of the English machine, and as they were received from the machine they were smooth and uniform but very soft, and on breaking them open there were spots that contained an excess of pitch, indicating that the materials had not been thoroughly mixed or that in passing from the pug mill to the press there had been an opportunity for the pitch to flow together. On cooling, however, these briquettes became very hard and tough. Another ton was made, running both sides of the disintegrator, which made smooth, uniform briquettes, but it was almost impossible to handle them as they came from the machine. Therefore, only one side of the disintegrator was used, but the materials were run through the pug mill more rapidly and better results were obtained. On becoming thoroughly cold, all of these briquettes were excellent in every respect. When these mixtures were tried on the American machine, the fine mass obtained by running both sides of the disintegrator made better eggettes than the corresponding briquettes of the English machine, while the coarser material did not make as good eggettes as briquettes. The weight of the briquettes obtained in running both sides of the disintegrator was 6.92 pounds each, while the coarser briquettes weighed 6.56 pounds each. The specific gravity of these briquettes was 1.17 and their crushing strength was 17,500 pounds per square inch.

Arkansas No. 5.—On account of the success obtained with these Arkansas coals and the softer pitches, it was decided to make a sufficient quantity of briquettes for a locomotive test on the Missouri Pacific Railroad. For this purpose 17 tons of Arkansas No. 5 coal were briquetted with 6 per cent of pitch C, which was a trifle harder than pitch B. Excellent briquettes were obtained, which were readily handled while warm, and on cooling stood a good deal of very rough handling. They did not break so readily as the original lumps of coal. The briquettes were tested on a locomotive of the Missouri Pacific Railroad, and for comparison similar runs were made on an Illinois run-of-mine coal such as is commonly used on these locomotives. Three trips were made from St. Louis to Washington, Mo., and return, making a total run of 324 miles for each fuel. The results of these three runs are given in the tables following.

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[a] For result of test see p. 80.

Locomotive test of briquettes of Arkansas No. 5 coal.

Date.	Briquettes consumed.	Ash removed.	Front-end cinders removed.	Total coal consumed.	Total ash removed.	Per cent of ash.	Miles to ton.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*		
November 28	9,720	1,250	194				
November 29	10,049	1,535	182	29,594	4,615	15	21.89
November 30	9,825	1,226	228				

Locomotive test of run-of-mine Illinois coal.

Date.	Briquettes consumed.	Ash removed.	Front-end cinders removed.	Total coal consumed.	Total ash removed.	Per cent of ash.	Miles to ton.
December 1	11,265	1,980	130				
December 2	11,050	1,558	112	34,015	5,695	16.4	19.05
December 3	11,700	1,800	115				

A further test of Arkansas No. 5 coal was made by mixing pitches C and A up to one-fourth of the soft pitch C and three-fourths of the hard pitch A, and a briquette of good quality was obtained, but it was not equal to the briquette made with 6 per cent of pitch C. With more than three-fourths of hard pitch, it was necessary to increase the percentage slightly, to use more steam for heating and a greater pressure, and the resultant briquettes were considerably inferior and more crumbly.

Arkansas No. 6.—This coal was briquetted with 8 per cent of pitch A and made a briquette of fair quality. These briquettes were made in order to test the coking value of the mixture, and this work is described on pages 122 and 168.

COLORADO.

Colorado No. 1.—The only coal that was tested from Colorado is a black lignite, which was first used undried with 10 per cent of pitch D. As these briquettes were received from the machine, they were hard to handle, especially when there was an excess of steam. The pitch did not seem to adhere to the grains of lignite. On cooling, however, they became hard, black, and lustrous, but were too brittle. The adhesion of the pitch to the grains of lignite was not very great. The briquettes seemed to be too pitchy, and if the adhesion between the pitch and lignite were greater 8 per cent would undoubtedly be suffi cient to give the desired results. Although there was no steam test made with these briquettes, they were burned under one of the boile and proved quite satisfactory. They weighed 5.98 pounds each. Son of the same mixture was tested on the American machine, but th eggettes were much inferior to the briquettes.

ILLINOIS.

Illinois No. 1.—Briquettes from this coal were first made with the hard pitch X as a binder. One and a quarter tons of this coal were briquetted with 16 per cent of pitch X, but on account of the softness and roughness of the coal the briquettes were brown and very soft, resembling pressed damp loam. They were, however, compact and well pressed.

Illinois No. 4.—Two tons of this coal were briquetted with 6 per cent of pitch D. The coal was not ground very fine, there being but one side of the disintegrator used. There was a great deal of water in the steam, with the result that the briquettes were full of the usual perpendicular cracks. Very great pressure was used, and some of the briquettes were larger than the normal size, which was due to the compression of the spring of the machine. The average weight of these briquettes was 6.95 pounds. The briquettes varied considerably in texture, some being hard and firm while others were crumbly. On cooling, the briquettes were hard and firm, but would not stand very much rough handling. The specific gravity of these briquettes was 1.16, and their crushing strength was only 5,100 pounds to the square inch. Some of these mixtures were also tried on the American machine, and the eggettes were better than the briquettes made on the English machine. They were lustrous and had a deep black color.

One ton of this coal was briquetted with 8 per cent of pitch D, using but one side of the disintegrator and with the maximum pressure. Splendid briquettes were obtained with this combination, but they were gray in color. They weighed 6.43 pounds each and had a specific gravity of 1.11. The specific gravity of the coal is 1.34. The crushing strength of these briquettes was 9,327 pounds, as compared with 5,100 when 6 per cent pitch D was used as a binder. The eggettes made of this mixture on the American machine were not so strong as the briquettes.

The next test made with Illinois No. 4 consisted of 2 tons of the coal briquetted with 8 per cent of pitch E. The average weight of the briquettes was only 6.15 pounds. Only one side of the disintegrator was used, and as the coal was hard the briquettes were coarse and contained many noticeably large pieces of coal. The eggettes made from this mixture, on the other hand, were much better in quality and quite lustrous, but of a decidedly brownish color. The specific gravity of these briquettes was 1.13 and their crushing strength 7,265 pounds to the square inch. To test the effect of finer grinding, another ton of this coal was briquetted with 8 per cent of pitch E, using both sides of the disintegrator. In these briquettes there were a few grains of coal as big as a kernel of corn; but for the most part the material was too fine for the percentage of pitch, and the resultant briquettes were crumbly,

although well pressed, black, and lustrous. They weighed on an average 6.5 pounds each and had a specific gravity of 1.03. Their crushing strength was only 6,000 pounds to the square inch. There was little difference in the properties of the eggettes made of this mixture and the briquettes. Another ton of this coal was briquetted with 9 per cent of pitch E, using both sides of the disintegrator with a maximum pressure, with the result that a briquette of much better quality was obtained. They could, however, have been still further improved by the addition of another one-half per cent of pitch. The weight of these briquettes was 6.43 pounds each and their specific gravity 1.08. Their crushing strength was 9,125 pounds to the square inch. The eggettes made from this mixture were equal in strength and quality to the briquettes and were much more lustrous and bluish black in color.

Another test was made with Illinois No. 4 coal and pitch H, which is a by-product from the manufacture of gas from heavy petroleum. While this pitch would be rather soft to work on the English machine on a hot day, it is readily cracked and mixed on a cold day. One ton of the coal was briquetted with 8 per cent of pitch H, and the resultant briquettes were very strong, clean, and satisfactory, being very much better than any of the other briquettes made with this coal. They were readily handled when taken from the machine, and when cold were very hard and tough, and were capable of standing a great deal of rough handling. Their average weight was 6.81 pounds each and their specific gravity was 1.11. Their crushing strength was 12,810 pounds to the square inch, this being the greatest of all the briquettes made from Illinois coal.

The last test made with this coal was with a soft asphalt received from the Gulf Refining Company. In freezing weather this asphalt became hard enough to crack and thus could be used on the English machine. On account of the cold weather, there was considerable water in the steam, which produced cracks. Because of this fact and the low melting point and thinness of the asphalt while hot, the briquettes were difficult to handle as they came from the machine. They were, however, well pressed and on cooling became tough and would stand much handling. A better result can probably be obtained by using a small percentage of rosin with the asphalt.

INDIANA.

Two coals from this State were tested more for comparative purposes than with regard to their commercial possibilities.

Indiana No. 1.—Four tons of this coal were briquetted with 7 per cent of pitch D.[a] The coal was first washed and then dried. The briquettes were brown in color, readily handled as they came from the machine, and when cold stood rough handling. The average weight

[a] For results of steam test see p. 80.

of the briquettes was 6.8 pounds each. The eggettes of this mixture, made on the American machine, were better and stronger than the briquettes.

Indiana No. 2.—One ton of this coal was briquetted with 7 per cent of pitch H, and the resultant briquettes were satisfactory in every way. They were brown in color and resembled those made of Indiana No. 1 coal, but were much stronger, due to the better quality of pitch. They weighed on the average 6.42 pounds each.

INDIAN TERRITORY.

Indian Territory No. 2.—This coal was tested with the hard pitch X, using first 8.5 per cent of pitch; but the briquette was not strong and crumbled very readily. With 12 per cent of pitch the briquettes were not much better, and with 13.4 the briquettes looked well as they came from the press, but were not strong and began to lose their corners soon after being exposed to the weather. Judging from the runs made, this coal will require more than the usual pressure. The briquettes containing 8½ per cent of pitch weighed only 5.08 pounds each. Those with 13.4 per cent of pitch weighed 6.15 pounds each.

Indian Territory No. 3.—This coal, which is hard and glossy, was tested on the English machine with 8 per cent of pitch A. This made fairly good briquettes, which were clean and hard, although somewhat porous, but they were not so strong as was desired. This defect was due in part to lack of sufficient heat in the pug mill to thoroughly soften the pitch. The briquettes as received from the machine weighed 6.56 pounds each. With 7.2 per cent of pitch A, this coal made smooth and fairly hard briquettes, which weighed 6.71 pounds each. With 6 per cent of pitch A, briquettes were made of this coal that were smooth and well pressed, but soft. These averaged in weight 6.8 pounds each. If this pitch could have been heated in the English machine to a sufficiently high temperature to cause it to soften and mix with the coal, it would undoubtedly have made a very good briquette; this is indicated by the fact that with a soft pitch, as pitch D or pitch H, this coal could be briquetted with 6 per cent of binder.

Indian Territory No. 6.—This sample consisted of a carload of very dirty slack, which contained considerable fire clay and some shale. Laboratory experiments had shown that 7 per cent of a binder of the quality of pitch D was the minimum that could be expected to give satisfactory results. Accordingly, one ton of this coal was mixed by hand with 7 per cent of pitch D, but the resultant briquettes were very crumbly and not at all satisfactory, although dense and well pressed. They weighed 7.35 pounds each. They were full of gray streaks on the surface, due to the fire clay, and on standing became coated with a heavy gray efflorescence, which was tested and proved to be calcium

sulphate. Eggettes of this same mixture made on the American machine were practically the same in character and unusually dull grayish in appearance. The specific gravity of these briquettes was 1.205. When tested upon the compression machine these briquettes, which were very crumbly and weak and broke rather readily in the fingers, compressed much more than usual before breaking. Their crushing strength was 5,600 pounds per square inch. Another ton was tried with 9 per cent of pitch D, but the resulting briquettes were practically the same as with 7 per cent, although a little darker in color. They also showed similar streaks of fire clay on the surface and their fracture was decidedly earthy. They weighed on the average 7.5 pounds each. There seems to be but little adhesiveness between this pitch and the dirty coal, and to make a good briquette with this pitch it would be necessary to use probably as much as 15 per cent or more.

Satisfactory results with soft pitch not having been obtained, one ton of this slack coal was tried with 8 per cent of the harder pitch A. The briquettes were well pressed and blacker than those with 7 per cent of pitch D, but were not so strong. There was not the slightest tendency for the mixture to become stiff in the machine, which is a further indication of the destructive character of this coal on the properties of the pitch.

This coal was next tried by mixing together 93 per cent of coal, 6 per cent of rosin, and 1 per cent of quicklime. The lime was mixed in lumps from dust to three-fourths of an inch in diameter, which it was expected would be reduced by the disintegrator and slacked by the steam of the pug mill, so that the cement would not set too quickly. The disintegrator, however, had very little effect on the hard lime, and consequently there were many large unslaked pieces in the resulting briquettes, which caused them to fall to pieces. Some of this material that remained in the pug mill for some time gave a briquette that was hard while hot, but after cooling the briquette became earthy. These briquettes weighed on an average 7 pounds each. The eggettes made of this material were dense, but very crumbly.

In order to overcome the chances of unslaked lime going into the briquettes, the lime was slaked before using with one-half its weight of water, making a fine, dry powder. This was mixed with the coal to give the same proportions with the rosin as in the above test, and although the briquettes were smooth and well formed, having been thoroughly pressed, they were crumbly and not at all strong. They were grayish in color and similar in quality to those made with 7 per cent pitch D. They weighed on an average 7.5 pounds each. The eggettes of this same material were very crumbly and dull in luster.

Some of these lime-rosin briquettes were burned, and they were

found to give less smoke than those with the rosin and no lime, and some less even than those with pitch alone.

Another test of this coal was made with rosin and Kansas crude oil. The experiments in the laboratory had shown that the best results could be obtained by using 6 per cent rosin and 1 per cent of the oil. In preparing this combination for the English machine, the oil was first mixed with five times its weight of fine coal, so as to make a non-sticky mass that would readily mix with the cracked rosin and coal in the usual manner. On account of the rosin becoming very fluid at 212° F., the hot briquettes as they were received from the machine had no strength, and cracked slightly under their own weight when piled only two high. They also cracked rather badly owing to the water from the wet steam. On cooling they became strong and were of good quality. Some of the mixture that was allowed to stand in the mold before pressing until cool enough to be plastic was very good as received from the machine, but it had not been sufficiently pressed. On standing, these briquettes became coated with a heavy brownish-gray efflorescence. The weight of these briquettes averaged 7.29 pounds each and their specific gravity was 1.25. The crushing strength of the briquettes was on the average 6,400 pounds per square inch. On account, however, of the lack of uniformity of the briquettes, the results of 8 tests varied from 4,300 to 9,240 pounds. The eggettes made from this same mixture were hard and compact, although of a dull color, and they had a good degree of strength as received from the machine. With an arrangement for cooling the mass after it has passed through the pug mill and before being fed to the press, this mixture would make briquettes which would be very good physically, but which would smoke rather badly.

Since the above tests showed that the best way to counteract the effect of the large amount of fire clay in this coal was to add some liquid binder which would soak into it and yet at the same time unite with the solid binder, another test was made with creosote as a liquid binder and pitch as the hard binder. For this purpose Indian Territory No. 6 coal was mixed with 8 per cent pitch G and 1¼ per cent of creosote, such as is used in preserving timber. The creosote and five times its weight of fine coal were first mixed together and then thoroughly mixed with the cracked pitch and coal. In operating the machine with this mixture, the amount of steam used for heating the mixture was gradually increased until there was an excess. This, however, had no effect upon the cooled briquettes, but it made the hotter ones more tender and a little harder to handle. The first briquettes of this mixture cracked a little, due to excess of water, but the remainder came from the machine strong enough to bear handling at once. The effect of the excess of steam was to insure more complete softening of the pitch and more uniform mixing of the clay. These bri-

quettes were black and clean and only slightly streaked with the clay. When piled up they stuck together slightly, and were mottled a little from the creosote. They have, however, much less of the gray efflorescence than any of the Indian Territory No. 6 briquettes that have thus far been made, and are also the best that have been made, although still earthy. They are smooth and black, and although crumbling but little or not at all in handling, on breaking for firing they will crumble a great deal. The eggettes, on the other hand, made of this same mixture on the American machine are just as strong and would need no breaking in firing. The weight of these briquettes was 7.25 pounds each on an average. The specific gravity was 1.215, and their crushing strength was 6,500 pounds to the square inch.

Another test with the Indian Territory No. 6 coal was with the asphalt B5, which during the cool weather had become hard enough to crack, and thus could be readily used on the English machine. One ton of this coal and 8 per cent asphalt were used, which made briquettes that were soft and hard to handle while warm, especially when they contained moisture due to the wet steam. The better ones were compact, heavy, and tough, and although they had an earthy, oily appearance, did not crack when struck a severe blow. They would stand rough handling, but would be improved with a small percentage of rosin. These briquettes weighed 7.12 pounds each, and had a specific gravity of 1.22. Their crushing strength was very low, averaging 3,200 pounds per square inch. In making the compression tests the briquettes yielded a great deal before breaking and would be stronger under a quick load. The results varied from 1,800 to 5,100 pounds.

On obtaining a sample of pitch H it was decided to try the effect of this pitch on the Indian Territory No. 6 coal. The best results were obtained with this as a binder. One ton of coal was mixed with 8 per cent of pitch H, and with nearly dry steam and good pressure they made hard, compact briquettes. Although somewhat earthy, they would stand rough handling. Their average weight was 7.27 pounds each.

IOWA.

Iowa No. 4.—One ton of this coal was briquetted with 7 per cent of pitch E. The briquettes were well pressed, of a grayish color, but on cooling crumbled decidedly. They weighed 6.73 pounds each. As they did not contain an excess of pitch, 7 tons more of this coal were briquetted with 8 per cent of pitch E, in order to have a sufficient quantity for a steam test.[a] The resultant briquettes were bluish black in color, but they were not quite hard enough, although fairly strong and would stand considerable hard treatment in transportation. In burning they held together until consumed. They weighed, on an

[a] For result of this test see p. 81.

average, 6.77 pounds each. The eggettes made from this same mixture were stronger than the briquettes, had a polished surface, but were very brown in color. In the cook stove they burned very satisfactorily, without crumbling hardly at all.

KANSAS.

Kansas No. 2.—Two tons of this coal were briquetted with 11 per cent of pitch X. The pitch of the mixture, in passing through the machine from the pug mill to the press, set so quickly that the briquettes did not receive the necessary pressure. The surface was rough, and a great many cracks were developed. No more of this coal was available for briquetting after receiving pitch of the better qualities. It is, however, a coal that will briquette very readily with pitch of the better grades, such as pitch D or pitch H. It requires about 7 per cent of either for commercial briquettes.

KENTUCKY.

Kentucky No. 1.—This coal is a good coking coal, but is unusually light in weight and is very lustrous. In passing through the disintegrator it was ground a little too fine, even when using only one side of the machine. Then, again, on account of its light weight it was difficult to give it the right pressure on the English machine. The coal was tested with 6 per cent of pitch D, and the resultant briquettes were clean and black, but not sufficiently pressed to close all the pores. They were, however, very good briquettes, and would stand rough treatment in transportation. They stood weathering with but little change. They weighed on an average 6.15 pounds each. The eggettes made from this same mixture were very smooth and lustrous and as strong as any eggettes that have been made on the American machine. In the cook stove they burned very satisfactorily without disintegrating or giving off an excess of smoke. This coal can be briquetted very readily.

Kentucky No. 2.—As there were none of the good pitches available at the time this coal was tested, it was briquetted with 9 per cent pitch E, which was the percentage determined by laboratory work. Three tons of this coal were tested with 9 per cent pitch E. The resultant briquettes were extremely pitchy, and on account of the excessive water due to wet steam, these briquettes were difficult to handle, and when piled three or four deep they crushed under their own weight. With dried steam the briquettes were more easily handled. Although still somewhat plastic, they did not crush when piled up. On cooling, the briquettes were very hard, having a lustrous fracture, and were capable of standing a great deal of rough handling. These briquettes weighed on an average 6.83 pounds each. The eggettes

made of this same mixture were very hard and sonorous, but rathe too brittle. In the cook stove the eggettes burned very satisfactoril

This coal was tested with 8 per cent pitch E, using 3½ tons of co and giving the briquettes the greatest pressure possible on the Englis machine.[a] As the coal is very hard, only one side of the disintegrat was used, and in the resultant briquettes there were many large piec of coal, but there were also sufficient small pieces to fill in all the ope ings between the larger fragments. This is a nearly ideal conditic for briquetting on the English machine. The briquettes were bluis black and excellent in every way. They did not have the glossy c lustrous fracture of the briquettes containing 9 per cent of pitch, bu they were a better commercial briquette and were more easily handle when taken from the machine. With pitch of the quality of pitch D c pitch H, from 5 to 6 per cent would make a good briquette. These br quettes would stand a great deal of rough treatment in transportatio and in burning they did not disintegrate, nor was there much slac formed in breaking them for burning. They weighed on an averag 6.83 pounds each and had a specific gravity of 1.13, as compared wit 1.37, the specific gravity of the slack or fine coal. The slack whic was used in making the briquettes contained 18 per cent of ash, bu the lump coal contained only 11 per cent of ash. The crushing strengt of the briquettes was 11,300 pounds to the square inch. The eggett made from this same mixture were stronger and better than tho made with 9 per cent, although not so sonorous and hard. They we also browner in color. The eggettes were not so strong as t briquettes.

MISSOURI.

Missouri No. 1.—At the time this coal was tested only the hard pit was available. Two and a half tons of this coal that had been p viously washed were briquetted with 11.5 per cent of pitch A. T resultant briquettes were black in color and sufficiently hard to sta rough handling, but on account of the pitch setting too quickly th were insufficiently pressed and were granular and porous.[b] This c will, however, briquette very readily, and with the softer pitches, pitch D and pitch H, will make a good briquette with about 6 to 7 p cent of binder.

MONTANA.

Montana No. 1.—This coal was dried slightly before briquetti It was tested with 16 per cent of pitch A. The full limit of press that could be obtained on the English machine was used, and althou the briquettes were well pressed, they were somewhat porous rough on the surface. They were black, but not very glossy. T

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[a] For results of steam test see p. 81.

[b] For steam test see p. 81.

tood rough handling, and they weighed on the average 6.30 pounds ach.

This coal was briquetted with 7 per cent pitch B, using the highst pressure obtainable. As received from the press, these briquettes vere somewhat plastic, but on cooling they proved to be brittle. They veighed on an average 7 pounds each.

NEW MEXICO.

New Mexico No. 1.—This black lignite was first briquetted with 12 er cent pitch A, but the resultant briquettes were unsatisfactory in very way. Five and a half tons of this coal were briquetted with 5.8 per cent pitch X, and the resultant briquettes were apparently ood in every way and could be handled very easily vithout any rumbling. On cooling, however, they began to crumble, nd they did ot stand the weather very well. In burning they showed a great endency to disintegrate.

This coal was tested on the English machine with 8 per cent pitch D. he resultant briquettes were rather crumbly and earthy, and on coolng were covered with white efflorescence. They did not contain a ufficient quantity of pitch. They weighed on an average 6.83 pounds ach and had a specific gravity of 1.13. Their crushing strength was ,120 pounds to the square inch.

As 8 per cent of pitch D did not give any excess of binder, and as he resultant briquettes were not satisfactory, another ton of this coal as tested with 10 per cent of pitch D. While the briquettes fresh om the machine were somewhat stronger than those with 8 per cent pitch D, it was found that upon standing and becoming thoroughly ool they became so like those made with 8 per cent pitch that they ould not be distinguished from each other. This indicated that a tisfactory briquette could not be made with this pitch, even by eatly increasing the percentage. In making these briquettes, the nglish machine was run under ideal conditions, having a constant essure; the coal was sufficiently dry and not too fine, and could be iquetted at a moderate temperature. There was a little more white florescence on the briquettes with the 10 per cent than with the 8 r cent pitch D, although the briquettes were quite glossy. The erage weight of these briquettes was 6.42 pounds each and their ecific gravity was 1.02. The crushing strength of these was 5,900 unds per square inch, as compared with 7,120 pounds per square ch for those made with 8 per cent pitch D. The eggettes were quite ossy on the surface, but had a dull fracture and were not very acious. There was a tendency to disintegration in burning.

The most satisfactory test was with pitch H, and one ton of this coal as briquetted with 8 per cent of this pitch. The resultant briquettes

were hard, strong, and clean, being much better in every way than any briquettes of this coal made with pitch D. They weighed on the average 6.25 pounds each and their specific gravity was 1.06. Their crushing strength was 13,050 pounds per square inch, nearly twice the strength of those made with 8 per cent pitch D.

New Mexico No. 2.—This black lignite is almost identical with New Mexico No. 1. It was tested with 9.3, 10.5, and 12 per cent of pitch X, but in every case the resultant briquettes were very crumbly and no positive results could be obtained.

This coal was next tested with pitch D as a binder, one ton of the coal being briquetted with 7 per cent of pitch D. The resultant briquettes were very crumbly, gray in color, and had an earthy fracture. They were neither hard nor strong and were porous, although the pressure was increased to the limit. There did not seem to be any difference in the resultant briquette, whether made with a low or high pressure. There was a large amount of grayish efflorescence that came out on the briquettes almost immediately. They weighed on an average 7 pounds each. The eggettes made from this mixture, although not so porous, had the same earthy appearance and fracture and gray color.

Another ton of this coal was briquetted with 9 per cent of pitch D, and there was an excess of pitch, as was indicated by the bluish color on the external surfaces, due to partial volatilization of the pitch. On account of an excess of steam, the briquettes were rather soft as received from the machine, and owing to the excess of pitch many of them stuck together. Although they were better than those made with 7 per cent pitch D, they were not commercial briquettes. They weighed on an average 7.12 pounds each. This coal was very dirty and contained considerable clay, and the same difficulties were experienced in briquetting it with pitch as with the Indian Territory No. 6 coal. From the work that was done on this sample, it has been definitely proved that such dirty lignites can not be well briquetted with any commercial percentage of pitch as a binder, unless perhaps it is a pitch made from petroleum, as pitch H.

Five tons of this coal were briquetted on the American machine using 10.25 per cent of the Hoffman patent binder, consisting of petroleum, rosin, and quicklime. These briquettes were not very tough, but held together pretty satisfactorily when burned under the boiler.[a]

NORTH DAKOTA.

North Dakota No. 1.—This is a tough, woody, brown lignite, which does not disintegrate very readily. In the first test the lignite was not previously dried and was mixed with 10 per cent of pitch

[a] For steam test see p. 82.

Although the highest pressure possible was used, the resultant briquettes were very porous and had the appearance of an incoherent mass of chips. With 12 per cent of pitch A the briquettes were still porous and noncoherent, and on standing for some time exposed to the weather the grains and fragments of lignite began to slack off. Between the fragments of lignite there was an excess of pitch observed, but it did not seem to have any adhesion for the fragments. As the briquettes were cooling it was noticed that the contained steam acted upon the lignites, giving them the appearance of lumps of soft, brown loam surrounded by pitch.

The next test was made with dry material, the lignite having been previously ground to about 4-mesh. One ton of this dry, fine material was mixed with 12 per cent of pitch A and run through the English machine, only one side of the disintegrator being used. There was no excess of steam and the full pressure was used, but the resultant briquettes were open. With both sides of the disintegrator in use there was a slight improvement in the briquettes, but they were all a porous, incoherent mass, and on exposure to the weather began to disintegrate. There was apparently an excess of pitch between the flakes, similar to that observed in the first ton tested. The same mixtures were tested on the American machine, and the eggettes, when first received, had a polished, lustrous appearance, but became rough immediately, and they had almost no coherence. This lignite was tested further by increasing the percentages of pitch, allowing the mixtures to remain longer in the pug mill, and increasing the pressure to the limit that could be attained on the English machine, but no briquettes were obtained that had any coherence, and all the results were negative.

PENNSYLVANIA.

Pennsylvania No. 3.—This sample consisted of a car load of anthracite culm. The first test was with 90 parts of the culm and 10 parts of a West Virginia coking coal, and 12½ per cent of hard pitch A. The mixture was run through the English machine, both sides of the disintegrator being used, and the briquettes being pressed to the limit of the machine. On account of the hardness of the anthracite coal, it did not disintegrate to any great extent and the resultant briquettes resembled concrete. These briquettes were hard and tough, and even with this inferior pitch were of good quality. They weighed on an average 7.25 pounds each. During combustion they burned like lumps of anthracite coal, making but little flame. On standing exposed to the weather the briquettes did not suffer to any extent except during hard rains, when their surfaces became pitted. Apparently this pitting was due to the wearing away of the softer pitch from the harder fragments of anthracite.

grains of lignite. The fresh briquettes were difficult to handle, and when broken open the grains of lignite seemed to be wet, as if coated with moisture, which prevented the pitch from adhering to them. Many of the briquettes were porous, not being sufficiently pressed, and they were also brittle. Some of them, however, were quite good. When broken up and burned in the stove they stood up in the fire very well and burned better than any lignite briquette that had thus far been made. They weighed on an average 6.31 pounds each.

Another ton of this lignite was ground in the Williams mill and run through the drier, but this operation removed only a portion of the water, so that the briquette still contained considerable water. This material was briquetted on the English machine with 8 per cent of pitch H. A minimum amount of steam was used, which did not contain any excess of water, and a maximum pressure was applied. As received from the machine, many of the briquettes showed perpendicular cracks due to the excessive pressure. The hot briquettes were difficult to handle, the individual grains of the lignite seeming to be wet and not cohering at all. Even under their own weight many of them would crack badly. On breaking open the hot briquettes the grains of lignite seemed to move about as if they were alive. This lack of cohesion continued until the pitch became quite hard and could no longer be pressed in the machine. Thus the variation in the steam used as the mixture passed through the pug mill had no effect on the cohesion of the resultant briquettes. On cooling, however, these briquettes became very hard and strong and broke with a sharp fracture and with but a small amount of waste. In burning, these briquettes did not fall to pieces, as had been the case with the other lignite briquettes, but burned very satisfactorily. They were very light, weighing only 5.85 pounds each, and had a specific gravity of 0.98. The specific gravity of the coal was only 1.16. The crushing strength of these briquettes was 9,600 pounds to the square inch.

Another ton of this coal was tested with a soft, tough asphalt, B6, that was received from Casper, Wyo. As had been shown by laboratory tests, this asphalt could not be used on the English machine alone, and as a result the lignite was briquetted with 5 per cent of asphalt B6, $2\frac{1}{2}$ per cent of rosin, and 1 per cent of lime which had previously been hydrated. This mixture worked perfectly in the machine, and the hot briquettes were firm and good and easily handled, but the proportion of binder was not sufficient and the briquettes were dry and not strong. Another reason for this result was that during the two crushings and dryings of the lignite the grains had become of a nearly uniform size (about 10-mesh), so that the resultant briquettes were very porous in spite of the maximum pressure used. In burning, the briquettes fell to pieces. They weighed on an average 5.40 pounds each. A combination of this coal and asphalt can undoubtedly be obtained which will briquette satisfactorily.

COKE BREEZE.

In order to determine whether it was possible to use waste coke breeze, a series of experiments was made in the laboratory which showed that coke breeze could be briquetted so that it could be used as a substitute for lump coke. In order to make a practical test, a ton of this mixture was made containing 73 per cent of crushed coke, 20 per cent of West Virginia No. 6 coal, and 7 per cent of homemade pitch Y. These materials were mixed thoroughly by hand and run through the English machine, both sides of the disintegrator being used. They were well pressed, and as delivered by the machine they were unusually dry and had a brassy to bronze sheen on the surface, which looked as though it might be due to an abrasion of the brass of the molds. Upon testing this material, however, it was found to contain only the faintest possible trace of copper. The briquettes were hard and strong and easily handled while hot, but were somewhat dirty. On cooling they became unusually tough and strong, and during combustion were very solid and burned more like anthracite than bituminous coal. Such a combination would make a good substitute for anthracite coal. These briquettes weighed on an average 5.73 pounds each.

The same mixture was run through the American machine, and the resultant eggettes were dense, smooth, and polished, but not so tough as the corresponding briquettes. While warm they would stand a great deal of rough handling, but on cooling they became more brittle. This may be due to the crushing of the coke grains by the excessive pressure obtained in the American machine.

The next test of coke breeze was made without the introduction of any bituminous coal, and the mixture consisted of 92 per cent of coke breeze and 8 per cent of pitch D. In passing this mixture through the English machine both sides of the disintegrator were run, a minimum amount of steam was used, and a moderate pressure exerted. The resultant briquettes were clean, well formed, and when struck had a metallic ring. They were very tough and strong, and would bear much more handling than any of the briquettes made out of the coal. They burned like ordinary coke, without any disintegration and with only a little flame. These briquettes weighed on an average 5.92 pounds each. The well-pressed briquettes had a specific gravity of 1.025 and the porous briquettes had a specific gravity of 1.002. The crushing strength of the better briquettes was 30,100 pounds to the square inch, while the porous briquettes had a crushing strength of 2,100 pounds. In comparing the results of the crushing strength of these coke briquettes with those made from coal, it will be seen that even the porous briquettes had a much greater crushing strength than the best of the coal briquettes.

The eggettes of this same mixture that were made on the American machine were very hard and had the same metallic ring as the briquettes. On account of the fragments of coke being crushed in the press, these were denser than the briquettes, but not so tough. They were, however, very satisfactory. The manufacture of these eggettes or briquettes should be a means of utilizing a considerable amount of waste coke.

COKING OF BRIQUETTES AND BRIQUETTE MIXTURES.

In connection with the briquetting of the various coals, a line of experimental work suggested itself, viz, the possibility of making a coke out of a semi to non coking coal by the introduction of sufficient volatile matter in the form of a binder to cause the coal to coke. The first experiment along this line was tried with some of the briquettes made from Arkansas No. 4 coal and 6 per cent of pitch B, by filling a box with about 12 crushed briquettes and then placing this in one of the coke ovens, where it remained during a run of a coking coal. The result of this experiment was the obtaining of a mass of coke which was 12 to 15 inches long, somewhat metallic in appearance, and had a good ring to it.[a] The next experiment was the filling of a box with a mixture of Arkansas No. 4 coal with 6 per cent of pitch B, but without passing it through the press. This was treated in the coke oven similarly to the other, but the results were not so satisfactory as in the first case. A coke was obtained, but it was not so good as the other. The next experiment was with the same mixture after briquetting but without breaking up the briquettes. These were piled on top of one another in a box and tested in the coke oven in the same manner as the others. The result of this test was the obtaining of masses of coke that retained the form of the original briquette. All of the coke obtained by these experiments, while not of the quality desired for iron smelting, could be used for lead and copper smelting.

Another experiment on a larger scale was with 2 tons of Arkansas No. 6 slack coal. This coal was mixed with 8 per cent of pitch A and then ground in the Williams mill and charged into a coke oven together with an equal weight of the same mixture that had been previously briquetted. Both mixtures made coke, but not of the best quality. On account of the briquettes not being packed close together, a portion of them were somewhat burned and were not so good as the remainder.

The experiments seem to show that while a coke can be made by mixing coal and pitch, coke of a better quality is obtained by previously briquetting the mixture; but sufficient experiments along this line have not yet been made to justify any definite conclusions, and it is expected that the experimentation will be continued.

[a] For coking test see pp. 130–131.

	do	do	
hat crumbly	do	do	7,120
	do	do	5,900
rong	Good	Good	13,050
	Disintegrates	Disintegrates	
	Fair	Fair	
e cohesion	Disintegrates	Disintegrates	
	do	do	
ugh, good	Becomes pitted	Good, like anthracite	
	do	do	4,500
rong	Good	do	17,100
	Very good	Very good	
	Good	Good	
	Fair	Satisfactory	
, hard and	Good	Good	9,600
	Fair	Fell to pieces	

rown lignite.

Summary of briquetting tests.

Name of sample.	COAL.						BINDER.					BRIQUETTES.				
	Character and condition.	Chemical composition.				Specific gravity.	Per cent.	Kind.	Composition.		Specific gravity.	Weight in pounds.	General character.	Behavior on weathering.	Behavior on burning.	Crushing strength.
		Volatile matter.	Fixed carbon.	Moisture.	Ash.				Volatile matter	Fixed carbon.						
Alabama No. 1		31.84	53.28	2.34	12.54		7	Pitch A	47.93	50.79		5.12	Good	Slightly disintegrates.	Good	
Arkansas No. 1		17.46	66.69	3.24	12.61		9.25	....do					Poor, friable	Disintegrates	Poor	
Arkansas No. 2		16.02	72.65	2.23	9.20		11	Pitch X	59.07	39.44			Poor, porous	Poor		
Arkansas No. 3	Slightly moist	19.47	66.71	2.19	11.63		9.5	....do				6.8				
Do	....do						8.7	Pitch A					Very good, smooth and hard	Good	Held together until consumed.	
Arkansas No. 4	Slack					1.35	12	Pitch X					Incoherent	Disintegrates		
Do	....do					1.35	10	Pitch A				6.47	Good, compact	Good		
Do	....do					1.35	3 2	Rosin Pitch A				6.87	Clean, compact, but brittle.	....do	Some smoke, very good	
Do	....do					1.35	3 3	Rosin Pitch A			1.13	6.87	Clean, excellent	....do	Burn readily, no disintegration.	8,780
Do	....do					1.35	6	Pitch B	19.66	17.88	1.17	6.92	Excellent in every respect	No deterioration	No disintegration	17,500
Do	....do	12.82	73.69	1.28	12.21	1.36	3 2	Rosin Pitch B				7.20	Tender, friable			
Arkansas No. 5		12.68	72.88	2.36	12.08		6	Pitch C	62.75	35.84						
Arkansas No. 6		13.89	68.50	3.80	13.81		8	Pitch A								
Colorado No. 1[a]		34.88	40.45	18.68	5.99		10	Pitch D	51.05	43.91		5.98	Hard and lustrous, but brittle.	Slight deterioration	Satisfactory, little disintegration.	
Illinois No. 1	Soft	37.48	39.57	9.75	13.20		16	Pitch X					Like pressed damp loam			
Illinois No. 4		31.90	43.65	12.91	11.14	1.34	6	Pitch D			1.16	6.95	Hard, but rather friable		Some disintegration	5,100
Do						1.34	8	....do			1.11	6.43	Hard and tough	Good	Good	9,327
Do	Coarse					1.31	8	Pitch E	51.11	14.04	1.13	6.15	Not well pressed; somewhat porous.		Fair	7,266
Do	Fine					1.34	8	....do			1.03	6.50	Well pressed, but friable	Fair	....do	6,000
Do						1.34	9	....do			1.08	6.43	Good	....do	Good	9,125
Do						1.34	8	Pitch H	61.44	36.72	1.11	6.81	Clean, excellent	Good	Very satisfactory	12,810
Do						1.34		Asphalt B4				6.77	Tough, fair			
Indiana No. 1	Washed	35.17	40.41	16.59	7.83		7	Pitch D				6.80	Very good	Good	Very satisfactory	
Indiana No. 2		36.14	41.22	9.62	13.02		7	Pitch H				6.42	Clean, excellent	....do	....do	
Indian Territory No. 2	Hard	36.15	48.40	4.45	11.00		13.4	Pitch X				6.15	Poor	Crumbles	Poor	
Indian Territory No. 3		37.00	47.25	4.61	11.14		8	Pitch A				6.56	Fair	Disintegrates	Fair	
Indian Territory No. 6	Dirty slack	31.28	41.40	8.03	19.29		7	Pitch D			1.205	7.35	Dense, but crumbly	....do	Disintegrates	5,600
Do	....do						9	....do				7.50	....do	....do	....do	
Do	....do						8	Pitch A					....do	....do	....do	
Do	....do						6 1	Rosin Lime				7.00	....do	....do	....do	
Do	....do						6 1	Rosin Petroleum P3			1.25	7.29	Strong, good		Good, considerable smoke	6,100
Do	....do						8 1.25	Pitch Creosote			1.215	7.25	Good, crumbles slightly		Good	6,500
Do	....do						8	Asphalt B5	80.75	19.25	1.22	7.12	Tough, good		....do	3,200
Do	....do						8	Pitch H				7.27	Very good		Very good	
Iowa No. 4		35.59	39.37	14.08	10.96		7	Pitch E				6.73	Crumbles	Poor	Fair	
Do							8	....do				6.77	Strong, but not quite hard enough.	Good	Very good, no disintegration.	
Kansas No. 2		31.23	46.68	4.18	17.91		11	Pitch X					Poor	Poor	Poor	
Kentucky No. 1	Good coking	36.12	56.39	3.10	4.39		6	Pitch D				6.15	Good, slightly porous	Very good	Excellent	
Kentucky No. 2	Rather hard	37.91	45.02	7.91	9.13	1.37	9	Pitch E				6.83	Very hard and tough	....do	....do	
Do	Slack					1.37	8	....do			1.13	6.83	Excellent	....do	....do	11,300
Missouri No. 1	Washed	33.58	38.73	8.33	19.36		11.5	Pitch A					Pitch set too quick, porous.	Fair	Good	
Montana No. 1	....do	35.90	42.08	11.05	10.97		16	....do				6.30	Fair, rather porous	Good	....do	
Do	....do						7	Pitch B				7.00	Hard, but brittle	....do	....do	
New Mexico No. 1[a]		31.58	46.14	12.29	6.99		12	Pitch A					Very unsatisfactory	Crumbles	Disintegrates	
Do							15.8	Pitch X					Poor	....do	....do	
Do							8	Pitch D			1.13	6.83	Fair, somewhat crumbly	....do	....do	7,120
Do							10	....do			1.02	6.42	....do	....do	....do	6,900
Do							8	Pitch H			1.06	6.25	Hard and strong	Good	Good	13,050
New Mexico No. 2[a]	Slack	33.82	36.73	10.79	18.66		7	Pitch D				7.00	Crumbly	Disintegrates	Disintegrates	
Do.[a]	....do						9	....do				7.12	Earthy	Fair	Fair	
North Dakota No. 1[b]	Tough; not dry	20.59	25.68	35.38	9.35		10	Pitch A					Porous, little cohesion	Disintegrates	Disintegrates	
Do	Dry						12	....do					....do	....do	....do	
Pennsylvania No. 3	Anthracite culm	7.02	71.79	5.41	15.78	1.52	12.5	Pitch A, 11 parts West Virginia coal				7.25	Hard and tough, good	Becomes pitted	Good, like anthracite	
Do	Culm, 84 per cent					1.52	7 9	Pitch B West Virginia coal			1.174	7.64	Fair	....do	....do	1,500
Do	Culm, dried					1.52	7	Pitch B			1.28	7.10	Hard and strong	Good	....do	17,100
West Virginia No. 6		21.54	71.88	1.53	5.05		5	Pitch Y				6.12	Very good	Very good	Very good	
Do							3	....do					Good	Good	Good	
Wyoming No. 1[a]		35.68	37.19	22.63	4.50	1.16	9	Pitch H				6.31	Fair, porous	Fair	Satisfactory	
Do	Dried					1.16	8	....do			.98	5.85	When cold, hard and strong.	Good	Good	9,100
Do	....do					1.16	5 2.5 1	Asphalt B6 Rosin Lime	78.77	20.75		6.40	Poor	Fair	Fell to pieces	

[a] Black lignite.

[b] Brown lignite.

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PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Bulletin No. 261.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports. This bulletin is the fifty-fourth in Series A and the forty-fifth in Series E, the complete lists of which follow. (PP=Professional Paper, B=Bulletin, WS=Water-Supply Paper.)

SERIES A, ECONOMIC GEOLOGY.

B 21. Lignites of Great Sioux Reservation: Report on region between Grand and Moreau rivers, Dakota, by Bailey Willis. 1885. 16 pp., 5 pls. (Out of stock.)

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